25 SASKATCHEWAN SCIENCE & TECHNOLOGY ACHIEVEMENTS

Government of
Saskatchewan

105-05110/

25 SASKATCHEWAN SCIENCE & TECHNOLOGY ACHIEVEMENTS

Amazing Saskatchewan Science – Past, Present and Future

There's a whole lot of science going on in Saskatchewan. The province's scientists and researchers have achieved big breakthroughs in almost every area of science and technology.

Our scientists are helping the world address the major issue of global warming by designing non-polluting energy sources. They have attracted the attention of the world's scientific community through innovative research facilities like the Canadian Light Source synchrotron and the Petroleum Technology Research Centre. Their record for developing some of the world's best crops has helped build the diversified agricultural sector we know today.

Yet many people in Saskatchewan are unaware of these achievements. In 2005 – our province's Centennial year – it's time to learn more about important "firsts" that have made Saskatchewan a world leader in many areas of science and technology.

The goal of the SK25 project is to inform Saskatchewan residents – and in particular high school students – about the amazing scientific achievements of our province's past and present, as well as current research that will benefit our province and the world in the years to come.

About this project

In fall 2004, Saskatchewan Industry and Resources – the provincial department in charge of economic development – consulted several academic, government and industry organizations to assemble a list of Saskatchewan science and technology firsts.

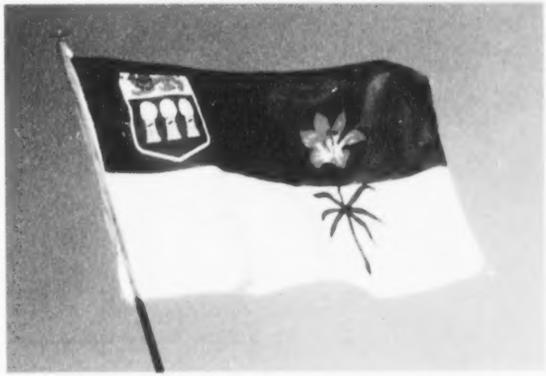
In November 2004, a selection committee made up of scientists and high school science teachers and students evaluated the firsts to determine the 25 with the highest scores to be profiled by this project.

The People Behind the Project:

Our thanks go to the members of the selection committee who volunteered their time to help us select the 25 achievements featured here:

- Dr. Katherine Bergman, dean of science, University of Regina
- Dr. Gerry Brown, vice-president, Agriculture and Biotechnology, Saskatchewan Research Council
- Daphne Cocks, science student, Winston Knoll Collegiate
- Jaffar Hasanie, science student, Campbell Collegiate
- Scott Langen, executive director, Saskatchewan Science Centre
- Tamzyn Liske, science student, Campbell Collegiate
- Valerie Mitschke, science teacher, Campbell Collegiate
- Dr. Ron Sutherland, professor emeritus of chemistry, University of Saskatchewan

We also want to thank the Canadian Plains Research Center for its contributions to producing the articles. Saskatchewan Learning provided valuable advice about structuring the project to meet the needs of grades 10 to 12 high school students.



They were asked to evaluate and score each first using the following criteria:

- impact on the first's particular area of science or industry
- impact on Saskatchewan's quality of life and economy
- whether the achievement was provincial, national or international in scope
- relevance to high school science students

Due to practical considerations, the project managers limited the achievements profiled to the 25 highest scores. However, we acknowledge that the selection committee worked under the limitations of the number of achievements provided for their consideration and the evaluation criteria established. Because of this, some important firsts could have been overlooked, and we will attempt to address these omissions in future phases of the project.

The Canadian Plains Research Center at the University of Regina helped research and write the profiles of each first for this project's booklet and website. Many of these firsts will also be featured in the *Encyclopedia of Saskatchewan*, which the center will publish in September 2005.

Special Thanks

The following organizations provided assistance in identifying achievements to be evaluated by the selection committee:

Ag-West Bio Inc.

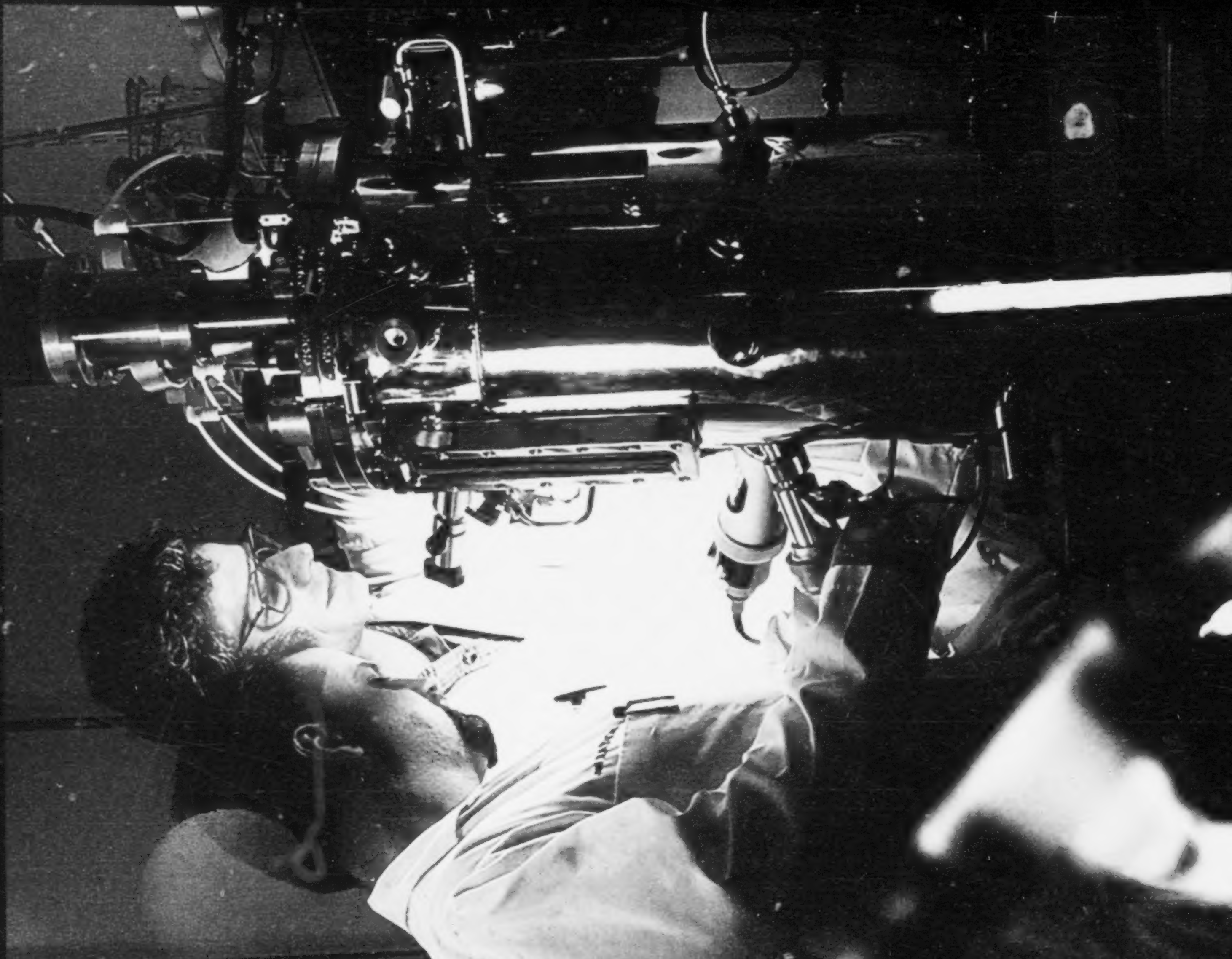
Saskatchewan Agriculture and Food

Saskatchewan Industry and Resources

Saskatchewan Research Council

University of Regina

University of Saskatchewan



This publication was produced in 2005 by Saskatchewan Industry and Resources.
For more information about the publication or to inquire about obtaining additional copies, contact:

Marketing Branch
Saskatchewan Industry and Resources
4 - 2103 11th Avenue
REGINA SK S4P 3V7
Telephone: 306-787-9553
E-mail: mshepherd@ir.gov.sk.ca

The contents of this publication can also be viewed at www.sk25.ca.

Permission to reproduce:

This material may be reproduced for educational purposes by non-commercial users for their own immediate use and not for profit, as long as the source is recognized. Requests to reproduce materials in this publication, in whole or in part, for other purposes should be directed to the contact information provided above.

ISBN Number: 0-9738066-0-5

Government of
Saskatchewan

Saskatchewan Centennial 2005

Career Opportunities in Saskatchewan Science: You could find the next science first!

Whether you see yourself performing experiments in a lab, operating the controls of a robot that does work too dangerous for humans, or flying the prototype of an experimental plane, these careers are all possible right here in Saskatchewan.

Dr. Laurier Schramm, President and CEO of the Saskatchewan Research Council (SRC), says science can open the doors to many rewarding careers in the province.

"As a scientist, I'd advocate making sure students take all or as many maths and sciences as possible – it leaves your options open. Traditional physical science-based careers are available, but there are also many careers built on a scientific background, like engineering, aviation, medicine and dentistry. You see a lot of blending of science with other disciplines, and that makes for people who are pretty sought-after."

One of the defining characteristics of a scientist is a need to know and understand how things work, and that's what drew Dr. Colleen Christensen and Ryan Wilton into careers in science in Saskatchewan.

Dr. Christensen works at Canada's largest science project – the Canadian Light Source (CLS) synchrotron in Saskatoon. She was headed for a health sciences career, but her first job after finishing her undergraduate degree at the University of Saskatchewan was at VIDO (Vaccine and Infectious Disease Organization) – and it completely changed her mind.

Dr. Colleen Christensen
is involved in livestock research with the synchrotron.

Bovine x-ray

"My first mentor encouraged me to have a career in science. Previously, I didn't have any career counselling or anything to go into science. My undergrad degree is in physiology. It was a pre-requisite for what I thought I wanted to do, which was be a physiotherapist or chiropractor."

After getting her PhD in animal sciences, Dr. Christensen was hired to work at one of the most exciting science projects in Canada – the synchrotron. At the CLS, she is the imaging project manager, which means she handles the logistics in managing projects where the synchrotron's light beams will be used to take "images" of substances being tested. "I'm involved in imaging everything from breast cancer to cow hooves."

As another part of her job, Dr. Christensen helps find new clients who might be able to make use of the research the facility provides, and she brings new projects to the synchrotron.

Ryan Wilton also found that his interest in science would lead to a career, but not without a few changes of direction along the way. His favourite subjects while attending high school in Regina were the sciences.

"Chemistry and physics go hand in hand and allowed me to better understand how the world works. Chemistry describes what happens on a molecular level when two species react. Physics defines the mechanics of how these interactions take place. Both sciences intrigued me in high school, and my interest carried through into university."

Wilton participated in the co-operative education program while taking his undergraduate degree in chemistry at the University of Regina. In addition to semesters spent in the classroom, he also tried different work experiences, which were invaluable in deciding on a future career.

"My advice is to get involved with co-operative education. It's the best way to really decide if you're in the field you want. In addition, you will develop contacts with various employers, resulting in opportunity for future employment."

Summer jobs at companies like Nexen and SaskPower helped him decide to focus on the applied sciences versus pure research. After completing a master's degree in applied science, he now works for SaskPower developing technologies for reducing harmful emissions from coal-fired power plants.

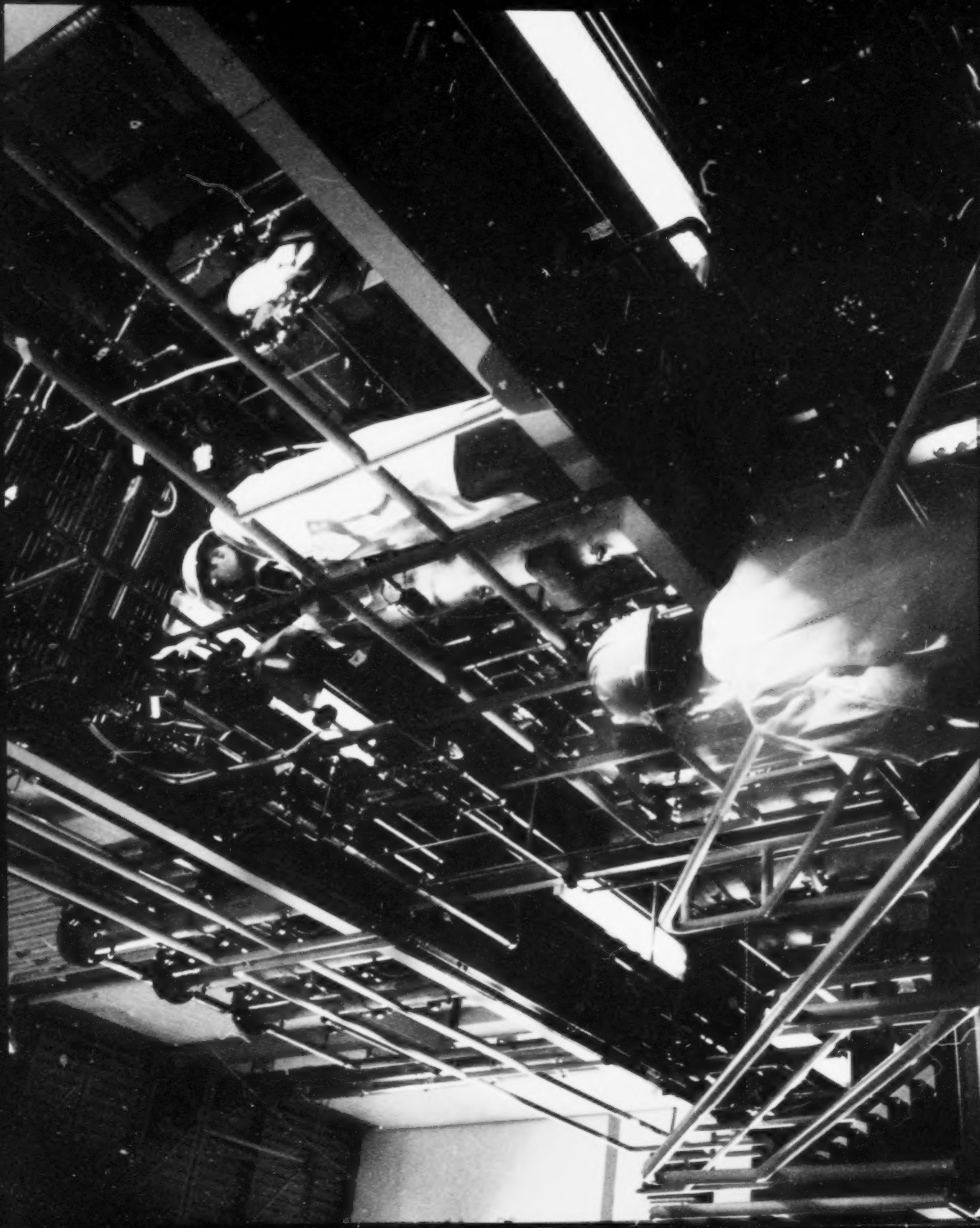
University isn't the only education route to a career in science and technology. For example, the Saskatchewan Institute of Applied Science and Technology (SIAST) offers classes in many science-oriented professions, including nursing, dental assisting and veterinary technology.

SIAST also offers nationally accredited programs in the growing fields of biotechnology and chemical technology. The biotechnology program equips students to do research in a number of industries. For example, in the agricultural industry, they could work in crop development – genetically altering plants to create new disease-resistant crops. Chemical technologists work in a number of different industries, doing everything from formulating new plastics to assisting with medical research.

The Saskatchewan Indian Institute of Technologies, operated by First Nations in the province, also offers programs in science-related fields. Students can sign up for programs in information technology, health science and Geographic Information Systems (which combines mapping with computer technology).

Dr. Schramm says there are many exciting opportunities in Saskatchewan to work at the forefront of international research and product development.

"It's so popular to compare ourselves with Alberta, which has this tendency to think 'YES, we can do that.' But it's the same in Saskatchewan – as long as we allow ourselves to think we can take things on. It's a lot about a state of mind…There's really nothing we can't do here."



Careers in Science 6

General Research and Development
Canada's first synchrotron in Saskatoon 15
Dr. Herzberg wins Nobel Prize in chemistry 19
Dr. Lemieux first to synthesize sugar 23
International project explores nature of matter 27
Trace analysis facility detects low-level pollutants 31
Titanic rusticle research helps improve water quality 35

Agriculture & Biotech
VIDO contributes world firsts in vaccine research 43
Saskatchewan scientists help develop canola 47
Crop researcher invents top malting barley 51
Building Saskatchewan's pulse crop sector 55

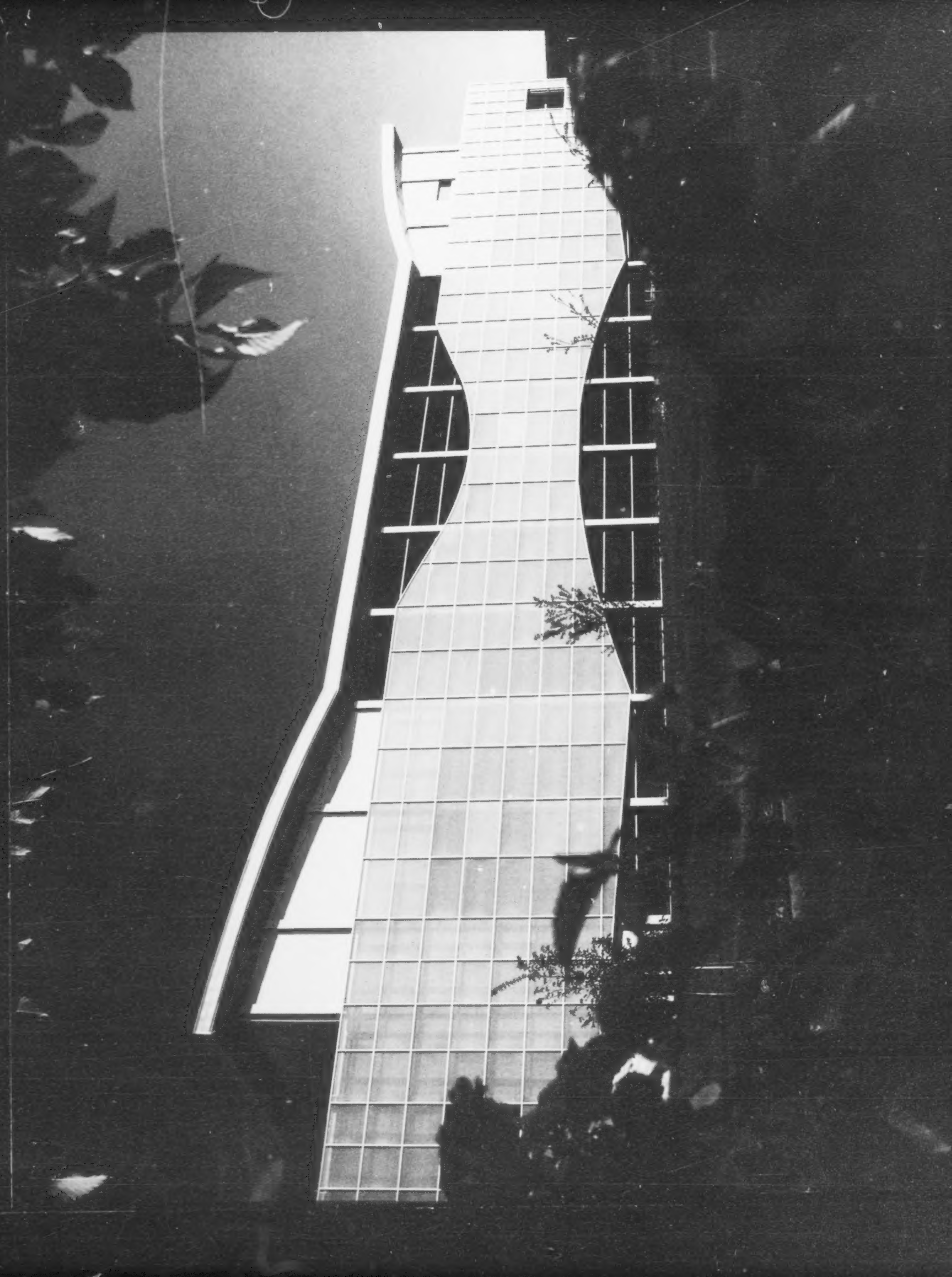
Medical Research
Pioneering cancer radiation treatment 63
Delivering medicine without painful needles 67
Waves in female fertility cycle 71
M-DNA molecule conducts electricity 75
Research to reduce chronic pain 79

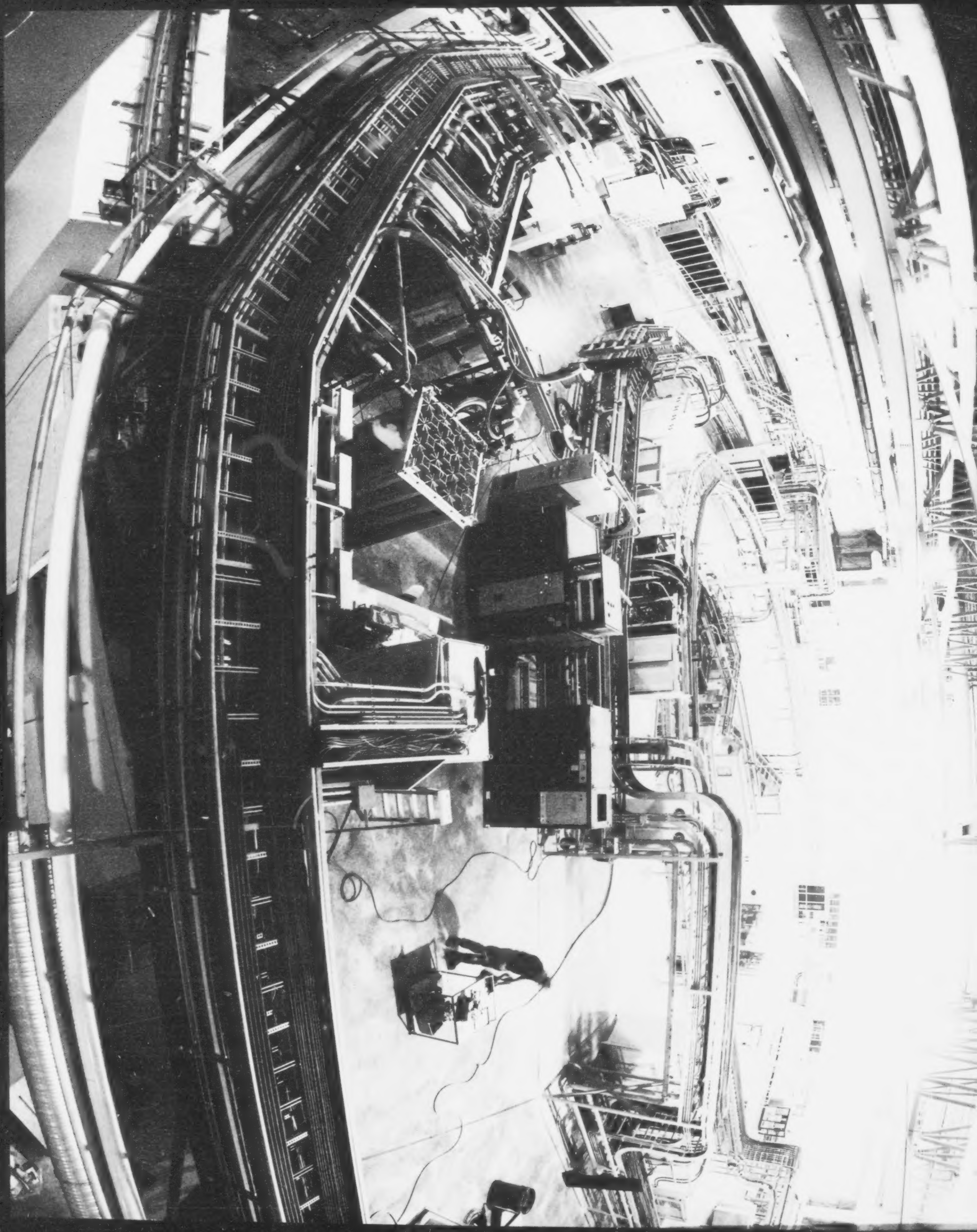
IT & Telecommunications
World's longest fibre-optics network 87
Canada's first automated teller machine 91
Super computer helps us understand matter 95
SED Systems antenna talks to spacecraft 99

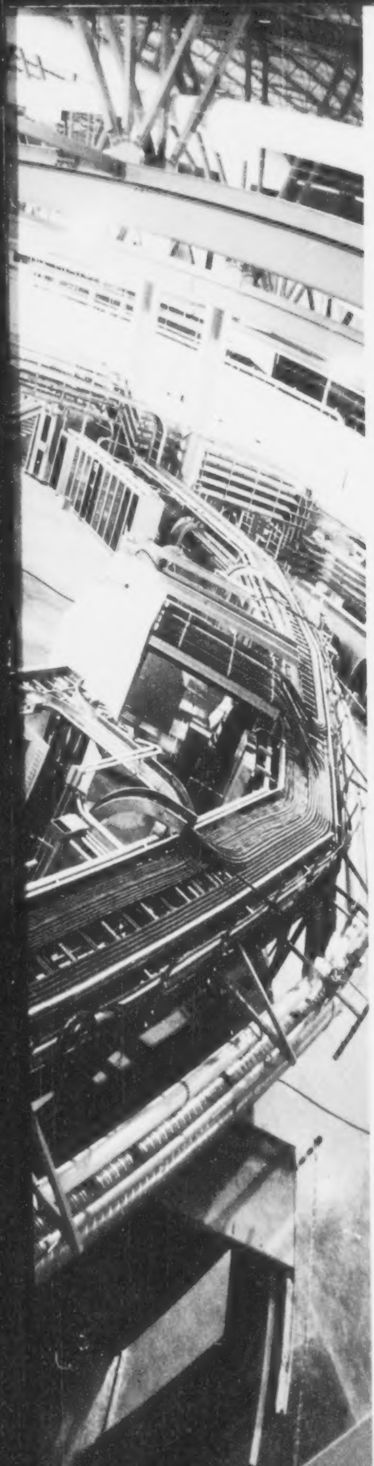
Energy
Weyburn oil project stores CO_2 107
Heavy oil upgrader helps expand industry 111
Hydrogen-diesel truck reduces greenhouse gas 115
Converting natural gas to cleaner hydrogen 119
Gardiner world's biggest earth-filled dam 123
Regina house pioneer in energy conservation 127

Photography Reference 130

General Research & Development







The Synchrotron: Canada's Light Fantastic

Imagine a research tool that produces light brighter than the sun and covers an area larger than a football field. Yet it helps scientists study the intimate workings of molecules and atoms.

Think it can only exist in science fiction movies? Think again. Since October 2004, such a research tool has been up and operating at the University of Saskatchewan.

Construction on the $174-million Canadian Light Source (CLS) synchrotron began in 1999. It is the country's largest science project in 30 years.

Sometimes referred to as "The Field of Beams," the synchrotron generates intense beams of light that researchers can use to conduct experiments to reveal the molecular structure of all forms of matter. This could lead to advances in almost every area of science and industry.

"The Canadian Light Source, Canada's first synchrotron, is an incredibly versatile tool for Canadian scientists and researchers from around the globe," explained Dr. William Thomlinson, executive director of the CLS.

This versatility is why scientists refer to synchrotrons as the "Swiss army knives of research." Of the 40 synchrotrons around the world, Saskatchewan's is one of the most advanced.

Until now, Canadian scientists and graduate students travelled to other countries to conduct their experiments on foreign synchrotrons. That trend will now be reversed. The Saskatoon synchrotron will receive about 2,000 visits each year from international researchers.

PCK protein (diabetes)

DID YOU KNOW?

A synchrotron generates intense beams of brilliant light millions of times brighter than the sun to view the microstructure of materials.

The Canadian Light Source synchrotron, which opened in 2004, is the biggest science project in Canada in more than 30 years.

Covering an area the size of a football field, the project cost $174 million to build with funding from federal, provincial and city governments, industry and academic sources.

A synchrotron produces a full range of the light spectrum from infrared to ultraviolet and beyond to X-ray wavelengths, providing a wide range of research opportunity for scientists.

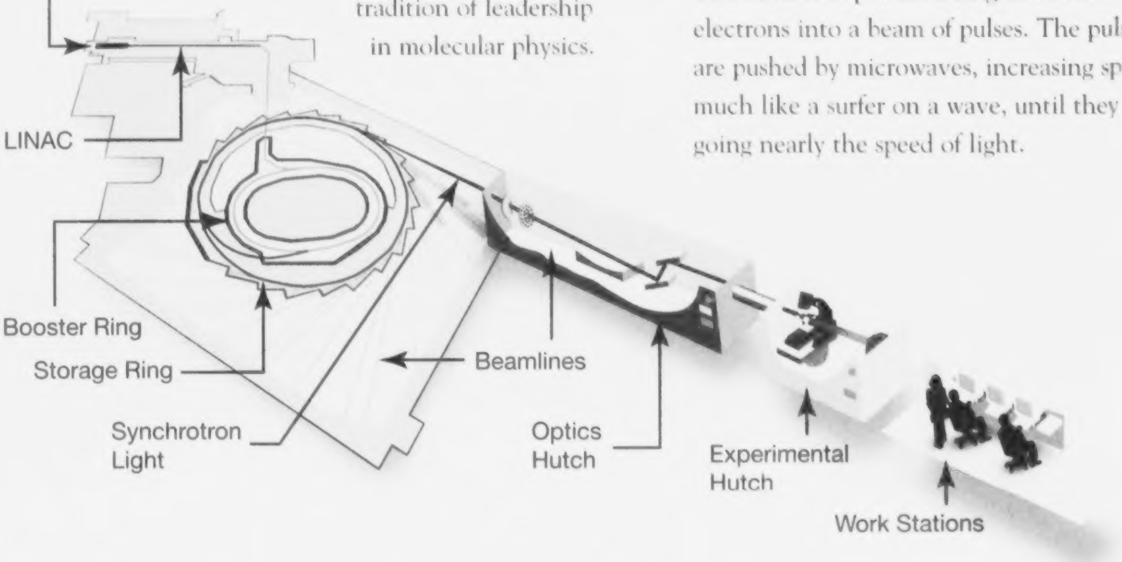
The Canadian Light Source produces a full range of light from infrared to X-rays. Researchers use synchrotron light to help design new drugs, clean up mining wastes, develop more effective motor oils, build more powerful computer chips, and develop new materials for safe medical implants – to name just a few possible applications.

The University of Saskatchewan won a national competition to build the Canadian Light Source. A major reason why the university was successful is its strong tradition of leadership in molecular physics.

In 1964, the university built a linear accelerator, or linac, used to accelerate electrons to investigate theories related to subatomic physics. Using the linac, the university enhanced its reputation in molecular research, which helped it win the synchrotron competition. The linac is now used to produce the electrons that the synchrotron needs to create light beams.

Here's a brief explanation of how the synchrotron works:

- The linac uses powerful magnets to form electrons into a beam of pulses. The pulses are pushed by microwaves, increasing speed much like a surfer on a wave, until they are going nearly the speed of light.



- The electron beam is transferred to a booster ring where microwaves speed it up even more, giving it more energy. Powerful electromagnets keep the electrons moving in a circular path around the ring.
- From the booster ring, the electrons are transferred into a storage ring. Electromagnets on the storage ring force the beam to change direction. When the direction of the high-speed beam is changed, a brilliant, full-spectrum beam of light is produced.
- These synchrotron beams are directed through beamlines where they interact with the molecular samples being tested. Each beamline is set up to use a different wavelength of light to test a different type of material. The information produced by the light passing through the material is sent to a computerized workstation where it can be analysed.

The synchrotron now has seven beamlines being commissioned or tested, and there are plans to have six more operating by 2007. The more beamlines there are, the greater the variety of materials that can be tested. There is capacity to create more than 30 beamlines.

Dr. William Thomlinson

Scientists currently working at the Canadian Light Source believe it will attract some of the brightest and best researchers in the world, who will work together across different disciplines to produce breakthroughs that they couldn't achieve alone. The synchrotron has put Saskatoon and Saskatchewan on the map as a hotbed for global molecular research.

ATP (universal energy storage molecule)

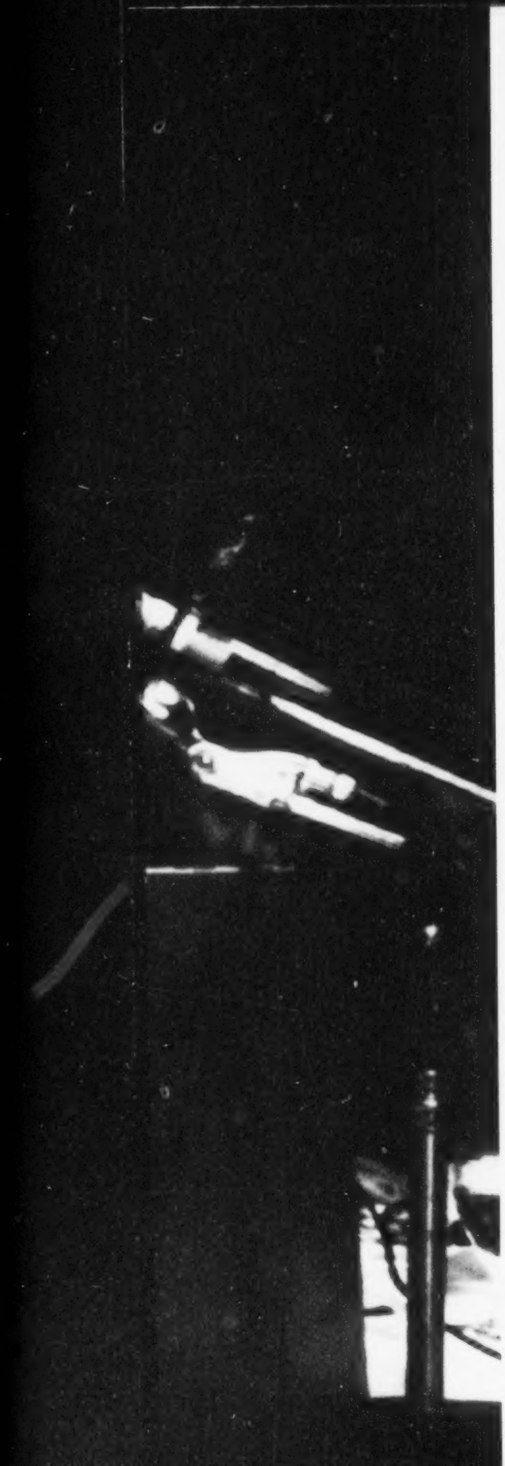
DID YOU KNOW?

Research in Saskatoon will focus on:

- biotechnology, pharmaceuticals and medicine
- mining, natural resources and the environment
- advanced metal and plastic materials
- information technologies and micro-systems

Current research using synchrotrons to develop new and better products around the world includes:

- creating better polymers for products such as super-absorbent diapers
- developing new drugs and vaccines
- investigating the effects of pollutants on the natural world
- manufacturing tiny biomedical implants



Former University of Saskatchewan Professor Wins Nobel Prize

Imagine a substitute teacher walking into your classroom one day who is the first Canadian to win a Nobel Prize in chemistry or physics! That was the experience of University of Saskatchewan physics students in the late 1970s when Dr. Gerhard Herzberg paid a visit to their classroom more than three decades after leaving the university.

During his time as a physics professor at the university from 1935 to 1945, Dr. Herzberg made significant progress in his study of the behaviour of molecules. His research in Saskatoon contributed to the body of work that resulted in a Nobel Prize in Chemistry in 1971. Dr. Herzberg was the first Canadian to win the prize for research in the natural sciences. Previously, the only other Canadians to win a science-related Nobel were Drs. Frederick Banting and John Macleod in 1923 in medicine for the discovery of insulin.

"Dr. Herzberg was very loyal to the University of Saskatchewan, visited many times after he left, and was very generous to us," remembers Dr. John Weil, a professor emeritus at the university who was a close friend of Dr. Herzberg. "One time, almost as a joke, I invited him to give my early-morning undergrad class a lecture on quantum statistics. He cheerfully acceded. You should have seen the students' faces!"

Dr. Herzberg joined the faculty of the University of Saskatchewan in 1935 when he and his wife moved to Saskatoon to flee from the Nazi regime in his native Germany. During his decade at the University of Saskatchewan, he wrote several books, which are to this day considered major authoritative works in the field of spectroscopy. By analysing spectrograms – a sort of photograph recording how different molecules emit and absorb light – he was able to significantly add to our knowledge about electrons and molecules. In fact, he is recognized internationally as one of the founders of molecular spectroscopy.

DID YOU KNOW?

Gerhard Herzberg was born on December 25, 1904, in Hamburg, Germany.

He moved to Saskatoon in 1935 to flee the Nazi regime in Germany.

Dr. Herzberg taught at the University of Saskatchewan from 1935 until 1945, during which time he wrote several books still considered the most authoritative works on spectroscopy.

In 1971, he became the first Canadian to win the Nobel Prize in Chemistry.

Dr. Herzberg died in Ottawa on March 3, 1999.

After leaving Saskatoon in 1945, he worked at the University of Chicago Yerkes Astronomy Lab for four years before returning to Canada to join the National Research Council (NRC) in Ottawa, where he set up a world-class spectroscopy lab. He was the director of physics at NRC from 1949 to 1969.

Dr. Herzberg won the 1971 Nobel Prize in Chemistry for using spectroscopy to discover the atomic internal geometry and energy states in 'simple' molecules, and in particular the structure and characteristics of free radical molecules. Free radicals are molecules that exist only briefly in chemical reactions where they come together and transform themselves into new types of molecules. In 1959, Dr. Herzberg was one of the first physicists able to capture and identify the structure and energy of a free radical molecule using a spectrogram.

CANADIAN NATIONAL TELEGRAM

STANDARD TIME

YA125 MARCONI

MO DARMSTADT 27 15/165H (CNT UNDERLINE ONE WD)

LC RP$3.29 SPINAS

121 UNIVERSITY SASK

ACCEPTANCE PROBABLE STATE PROFESSORSHIPS RESEARCH FACILITIES TEACHING DUTIES LATEST DECISON TERMS IS THREE YEARS CARNEGIE FELLOWSHIP TORONTO MONTREAL SASKATOON IMPOSSIBLE

HERZBERG.

He was awarded the prize in chemistry instead of physics because his discoveries had a significant impact on chemistry: his research helped explain how chemical reactions take place and also helped chemists imagine new ways to combine molecules to create new substances.

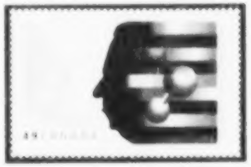
The physicist was known not only for his scientific brilliance but also his interest in serving humanity. "You shouldn't do science just to improve wealth – do science for the sake of human culture and knowledge," Dr. Herzberg once told a reporter.

The struggles he faced in his life might help explain his humanistic approach. In 1933, Dr. Herzberg was just 29 years old and lecturing at the university in Darmstadt, Germany, when the Nazis introduced a law banning men with Jewish wives from teaching at German universities. Because Dr. Herzberg had married a Jewish woman, Louise Oettinger, also a physicist, the couple began making plans to leave Germany.

Earlier that year, he had worked with Dr. John Spinks, a visiting physical chemist from the University of Saskatchewan. He had contacted several universities in North America in hopes of obtaining a position, but it was Dr. Spinks and the University of Saskatchewan who came through with an offer and helped him and his wife immigrate to Saskatoon.

Dr. Herzberg brought a German-made spectroscope with him to Saskatoon to begin his work in Canada. At the time, this type of equipment wasn't available in North America. He also brought his broad knowledge of physics, including his strong relationships with the science giants in Europe of the 20th century.

He continued his research well after his retirement from NRC and died in 1999 at the age of 94. Five years after his death, his achievements were recognized nationally when he was chosen to appear on a special 49-cent collector's stamp issued by Canada Post. NRC recognized his 20-year career there by naming a major facility after him: the Herzberg Institute of Astrophysics, a research facility in observational astronomy.



Dr. Herzberg continues to cast a giant shadow of influence across the Saskatoon campus to this day. "There is a growing Herzberg Fund to help support student research in chemistry and physics, as well as a Herzberg Scholarship," Dr. Weil said.

Dr. Herzberg is recognized internationally as one of the founders of modern molecular spectroscopy.

Dr. Lemieux First to Synthesize Sugar

Dr. Raymond Lemieux's achievement as the first scientist in the world to artificially produce common table sugar is amazing enough. What makes the discovery even more amazing is the circumstances under which it was made.

In 1953, while working at the National Research Council's lab in Saskatoon, Dr. Lemieux became the first scientist to create sucrose (the scientific name for table sugar) from its two component molecules – fructose and glucose.

Dr. Lemieux's discovery was dubbed the "research equivalent of climbing Mount Everest."

This achievement was monumental to carbohydrate chemistry and formed the scientific basis for many medical breakthroughs such as tests for blood group types and new vaccines. Dr. Lemieux's discovery was dubbed the "research equivalent of climbing Mount Everest," by Dr. Henry Gass, president of the Sugar Research Foundation in the U.S. Dr. Lemieux achieved this feat without the assistance of high-powered microscopes that scientists use today to view substances at the molecular level.

To understand the complexity of his work, you need to know some basic facts about sugars. Found almost everywhere in living systems, sugars are carbohydrate molecules made up of carbon atoms combined with the elements that make up water (hydrogen and oxygen). The way the carbon, hydrogen and oxygen atoms are arranged determines the type of carbohydrate molecule.

DID YOU KNOW?

Dr. Raymond Lemieux discovered synthetic sucrose, or table sugar, in 1953 while working at the Prairie Regional Laboratory of the National Research Council on the University of Saskatchewan campus.

Dr. Henry Gass, president of the Sugar Research Foundation, compared the achievement to the scientific research equivalent of climbing Mt. Everest.

Sugar is a carbohydrate that occurs naturally in every fruit and vegetable.

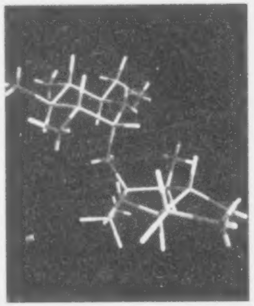
Sugar is the major product of photosynthesis, the process by which plants transform the sun's energy into food.

Carbohydrates are combinations of carbon (C), hydrogen (H) and oxygen (O). All carbohydrates are made up of one or more molecules of simple sugars and are classified by structure.

Dr. Lemieux had a much clearer understanding of the three-dimensional nature of sugar molecules and the structure and shape of the atoms that form these molecules than other scientists researching carbohydrates at that time. That knowledge enabled him to become the first to successfully "fit together" the atoms in the two separate molecules of fructose and glucose to achieve a chemical reaction that resulted in sucrose.

Sugars perform many other tasks besides giving us a quick energy burst when we eat them. For example, the shape of sugar molecules on the surface of blood cells determines what blood type we have. They also act as receptors for cell signalling (cells talking to one another). Sometimes, these sugar receptors are hijacked by bacteria and viruses, which can lead to disease. That's why antibiotics and some vaccines are formed from complex sugars that have just the right shape to connect with the sugar receptors on cells and prevent them from being hijacked.

Dr. Raymond Lemieux



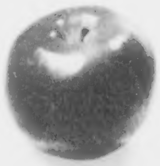
Sucrose molecule

Because his work helped scientists understand carbohydrate molecular structures more clearly, this research was an important step in the development of blood type tests, antibiotics and vaccines.

"He was simply brilliant," recalled Dr. Sue Abrams, a principal research officer at the National Research Centre's Plant Biotechnology Institute in Saskatoon. She now works in the same lab where Dr. Lemieux first synthesized sucrose and had worked as a researcher with him in the 1970s. "His work made him very famous in chemistry and biochemistry circles," she added. "We thought he should have been awarded the Nobel Prize."

Dr. Lemieux went on to lead a distinguished career full of new achievements. In the 1950s, he and colleague Dr. Ernst von Rudloff discovered a chemical reaction that was named after them and has been used for many commercial applications, including the manufacturing of nylon and other plastics. If you visit his old lab in Saskatoon, you can see the sink where he made his discovery, with a plaque commemorating it.

He left Saskatoon in 1954 to take up the challenge of building up the chemistry department at the University of Ottawa. After that, he went to the University of Alberta to develop its chemistry department. Dr. Lemieux continued to work with researchers at the University of Saskatchewan on structures of carbohydrates and proteins. He also found time to start three companies that produced industrial chemicals. He died in 2000 in Alberta – the province of his birth.



DID YOU KNOW?

Monosaccharides are one-molecule sugars such as:

- glucose (dextrose or blood sugar)
- fructose (levulose or fruit sugar)
- galactose (occurs mainly in milk)

Disaccharides are two monosaccharides linked together. Those common to food always contain at least one glucose molecule such as:

- sucrose (table sugar) = glucose + fructose
- lactose (milk sugar) = glucose + galactose
- maltose (malt sugar) = glucose + glucose

Polysaccharides are complex carbohydrates made up of simple sugars or their derivatives linked together in different ways. Those found in food include:

- starch – made up of several hundred glucose units joined together
- dietary fibre – consists of glucose, galactose or other monosaccharides linked together in such manners that the long chains are indigestible

Deep into the construction of the calorimeter module, a thickness of 15cm has been reached, containing approximately 13,000 4-m long fibres

Physics Project Helps Solve the Mysteries of Matter

Physics professors and graduate students at the University of Regina are among an international team trying to learn more about the "glue" that holds atoms together.

The international project, called GlueX, is bringing together some of the world's best minds in nuclear physics to learn more about the behaviour of particles called gluons, which are believed to play an instrumental role in holding matter together at subatomic levels.

This massive project involves more than 120 nuclear physicists and graduate students from 30 research institutions.

In the 1960s, scientists discovered the existence of quarks, subatomic building blocks that form the structure of the atom's nucleus. Further research showed that quarks seem "confined" together in combinations of twos or threes and do not exist alone. In the 1970s, scientists theorized that a new class of subatomic matter – gluons – was holding quarks together in these patterns. However, to this day, little is known about how gluons behave to achieve this hold.

"We really don't know how matter is created or why it is kept together," said Dr. George Lolos, head of the University of Regina's physics department. "We are just starting this project and have a long way to go."

The University of Regina's physics department is contributing one of the lead teams in this massive project that involves more than 120 nuclear physicists and graduate students from 30 research institutions. The Regina team, led by Dr. Lolos, is known as SPARRO (Subatomic Physics At Regina with Research Offshore).

DID YOU KNOW?

Subatomic Physics At Regina with Research Offshore, or SPARRO, is the name of the University of Regina group that is working with nuclear scientists and graduate students from 30 research institutions on a project called GlueX.

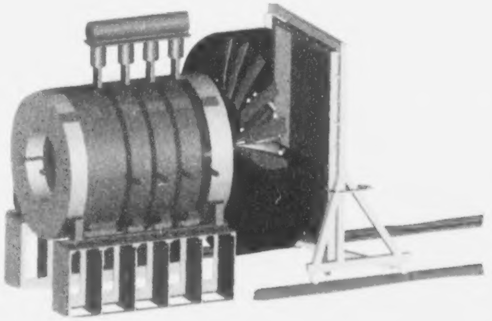
The purpose of GlueX is to determine how matter stays together.

For more than 25 years, physicists have suspected that subatomic particles unlike any other exist and are responsible for holding matter together. They have called these particles gluons.

The GlueX collaborators began their research in 1998. To study the gluons, the team is building a large detector with different components located at partner research institutions around the world. SPARRO is constructing the largest component – a cylinder about four metres long that will weigh 38 metric tonnes.

"It's the heart of the GlueX detector system because it detects all types of particles," Dr. Lolos explained. "It's a sandwich of thin lead sheets with special fibre-optic strands that create light when a particle passes through. We will need 4,000 kilometres of these fibres, enough to connect Vancouver to Toronto!" The entire GlueX detector system is expected to be fully operational by 2010.

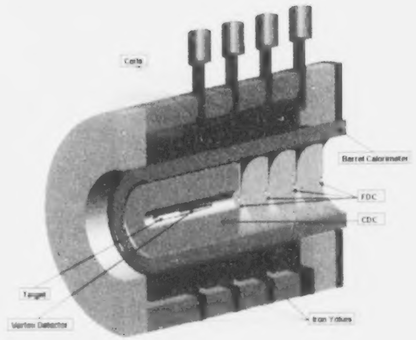
Studying gluons is not easy. They have no tangible structure and are invisible in ordinary matter. The GlueX team's approach is to study the energy patterns gluons leave behind after being involved in high-energy collisions created by the detector equipment. Although these energy trails cannot be tracked in ordinary matter, researchers have found that gluons leave behind an energy "signature" in so-called exotic matter, which does not normally exist in nature. The GlueX team will study the energy patterns of gluons during the formation of exotic matter.



Three-dimensional rendering of the entire GlueX detector, including the surrounding 2.2 Tesla superconducting solenoidal magnet (red/orange), the Cerenkov light detector (navy) and the lead glass calorimeter (turquoise).

The SPARRO team is taking an experimental approach to studying the physical behaviour of gluons, compared to the approach taken by another University of Regina physics team that is using a "super computer" to study the theoretic explanation of the behaviour of gluons and quarks. (This team's theoretic approach, called Quantum ChromoDynamics, is described in another article in this publication.)

GlueX is an example of pure research. "It is curiosity driven," Dr. Lolos said. "Nobody derives a direct benefit from it." Yet, he notes that instruments and tools used in medical and industrial applications today were once used only in the domain of physicists for pure research. He anticipates that the GlueX project will help create new, superior medical imaging equipment.



Three-dimensional rendering of the GlueX detector's innards. The calorimeter (green) is the responsibility of the Regina team.

GlueX researchers expect to publish their first results in 2010, and many leaders in the scientific community believe this research will be nominated for a Nobel Prize.

DID YOU KNOW?

Electrons were discovered in 1897, protons in 1911 and neutrons in 1936.

Elementary particles called quarks combine to form matter. Quarks are found in twos and threes, but never exist freely.

Preliminary test results are expected in 2010 for the project that some scientists already believe could be nominated for a Nobel Prize in physics.

Dr. Renata Bailey (left) and Patricia Hall (right)

New Lab Analyses Lowest Levels of Pollutants Possible

The new Trace Analysis Facility at the University of Regina will help researchers study pollutants found in our environment at concentrations so small that they are often undetectable. The facility, which will open in summer 2005, will be the most advanced of its kind in Western Canada.

Although such low levels of pollutants might not seem cause for concern, the facility's director, Dr. Renata Bailey, explained that they could be doing damage to our air, water and land in ways that we can't see.

A University of Regina team of researchers, led by Dr. Bailey, will use the facility to detect low levels of pollutants, studying their movement through the environment and their impact on it. To make this research possible, the facility will be equipped with the most sophisticated and complete instrumentation in Western Canada for this type of trace analysis, as well as the ultra-clean environment required to study such low concentrations.

"Because we are in a region of high pesticide use, it makes sense to locate such a facility here to study the impact of these compounds."

Initially, Dr. Bailey and the research team will focus on studying the presence of pesticides in Saskatchewan prairie ecosystems. Dr. Bailey will identify trace levels of pesticides, along with their sources, and track their movement, while other researchers will examine the long-term impact on wildlife populations. For example, international environmental research has documented the effects of pollutants on fish and bird populations, and the University of Regina team will search for and study any similar effects of pesticides on fish and bird species in local ecosystems.

PUF sampler used to sample semivolatile organic compounds like pesticides.

DID YOU KNOW?

- Without the instruments at the new facility, it can take up to two days just to prepare a sample for testing.
- There are over 200 registered pesticides in use in Saskatchewan.
- Saskatchewan uses more agricultural pesticides than any other province (36 per cent of the Canadian total).

"We will be able to contribute to an emerging area of environmental science," Dr. Bailey said. "Because we are in a region of high pesticide use, it makes sense to locate such a facility here to study the impact of these compounds."

The researchers will eventually study the effects of other low-level pollutants, such as pharmaceuticals, that find their way into the ecosystem.

The new lab will provide one of the cleanest environments around to prevent outside contamination of trace samples. "The levels of pollutants are sometimes so low that, in order to measure them, we have to ensure we're in a clean environment because otherwise we could contaminate samples while we are handling them."

The new facility will have a large, sealed clean room behind walls made of clear PVC (a type of plastic). Filters will keep the air supply clean, and anyone working in the room will have to use special coveralls for their clothes, shoes and hair.

Dr. Bailey is also looking forward to working with the lab's new instrumentation. Currently, the research team uses a GC/MS (gas chromatograph/ mass spectrometry) instrument to study trace substances. This instrument is similar to those used on the hit CSI television series to analyse trace evidence. However, it's not sufficient for the advanced research the team wants to undertake.

"The new instrumentation, such as liquid chromatography/tandem mass spectrometry, will enable us to see compounds that we usually can't, such as the breakdown products of pesticides," Dr. Bailey said.

The new facility will be a kind of "super lab" that allows researchers to process information and achieve results that are not possible using regular commercial or government labs. "These labs can't tackle the vast range of compounds at such low levels that can be transmitted through air or water supplies. Assessing how these compounds actually get into the ecosystem, how they move, and their impact, can help to manage their use much better."

The new instrumentation may also lead Dr. Bailey and her colleagues to improve on current research methods to establish new standards – speeding up analysis, lowering costs and enabling analysis of a range of sample types required for impact studies.

Dr. Bailey, who is a member of the university's Chemistry and Biochemistry Department, said the new facility will bring together researchers from other sciences both within the university and across Canada. She anticipates this will result in more comprehensive and innovative research breakthroughs.

DID YOU KNOW?

- When it opens in summer 2005, the new facility will be the most advanced of its kind in Western Canada.
- The new facility will be used to track trace levels of pollutants so low that it will be comparable to searching for a needle in a haystack.

Regina Water Scientist Makes a Titanic Discovery

When most people think of the Titanic, a certain movie featuring Leonardo DiCaprio and directed by James Cameron comes to mind. But the famous shipwreck, which Dr. Roy Cullimore sometimes refers to as the "Grey Lady," played a prominent role in the research around a mysterious community of microbes called rusticles.

The rust-coloured growths are all over the Titanic and other shipwrecks that have spent many years at the bottom of the ocean. Researchers at first considered the growths to be inorganic, rock-like formations, but Dr. Cullimore knew otherwise, and he had the chance to prove it on a 1991 expedition to the wreck of the Titanic. Using a special test for rusticles that he invented, called the BART (Biological Activity Reaction Test), he was able to demonstrate they were living organisms.

"At that time, a lot of people didn't believe rusticles were alive. I got three weeks' notice that I was to go on an expedition to Titanic and put the BART test to challenging use. The BART tests were never designed for depth, but I thought I'd try them – and they worked!"

During the 1991 expedition, Dr. Cullimore completed the tests on rusticles that had been retrieved from the ship and brought back to the surface for study. The tests told the world one of the most important things about the wreck – how much longer she will survive before she is broken down completely by these and other tiny organisms and given back to the sea.

The BART tests even worked on rusticles when the testers were placed right down on the deck of the Titanic for the first time on a 1996 expedition.

Rusticle growth over a gun pod on the Bismarck

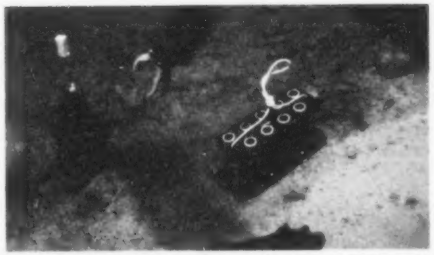
DID YOU KNOW?

Number of shipwrecks Droycon has studied: 13.

Dr. Cullimore's team are the only people in the world to have experiments permanently on the Titanic. Some have just come back after six years on the ship.

Dr. Cullimore's team designed part of a touring Titanic science exhibit that has been around the U.S. by supplying a rusticle they were able to grow in their lab.

Dr. Cullimore studies rusticles as living iron microbial communities that are growing on the Titanic and many other shipwrecks deep under the ocean. He first began his work on what he calls the "strange beasts" in the 1970s while working as a professor at the University of Regina. His long-term study of rusticles began when someone asked him what he knew about iron bacteria. His response?



Mark I and Mark II platforms are used to study the biological deterioration of steel.

"Nothing right now."

But the question was enough to inspire him to find out much, much more about these beasts of the deep. Rusticles, as he discovered, are living concrete organisms populated with tiny little iron bacteria that grow and form where there is plenty of water, lots of iron and the chemicals of life. He first began looking at them in prairie water wells, places he describes as "out of sight, out of mind."

Dr. Cullimore and his colleagues developed the BART tests in the mid-1980s to understand how the rusticle bacteria form and grow. They came up with the test for rusticles, as well as a treatment to control rusticle infections underwater. Out of that test grew a way to both apply his research and generate revenue for his Regina-based company, Droycon Bioconcepts Inc., which he still runs today.

There are several kinds of BART tests that can be used for detecting many kinds of contamination in water supplies – they can test for clogging, sliming, plugging and hygiene risks in wells, streams, lakes and even drains. It is possible to determine levels of different kinds of bacteria in water sources, and also the severity of bacterial infections in water and soil.

But the "strange beasts" that Dr. Cullimore has studied for more than 30 years have many more applications. Currently, Droycon is involved in several different projects that all apply what he and his colleagues have learned about rusticles. "The great thing about rusticles," he explained, "is they don't need stainless steel or squeaky clean environments to grow. They just dominate wherever they are if there is salt, iron and enough nutrients."

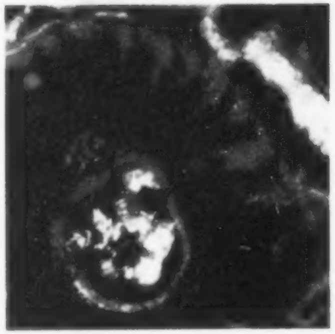
One of the projects is taking place in a system of pipes and tubing that Dr. Cullimore affectionately calls "Gurgle" because that's the sound the rusticles inside the pipes make as they release their mysteries into the water. Gurgle is part of the experiment to develop an antibiotic using rusticles. Their ability to dominate other bacteria under certain conditions could be used to make a new kind of antibiotic.

"The rusticles produce chemicals that reduce competition from other organisms. It's not one single organism doing this, but it's the community. The group works together as a team to stop competition."

In 2005, Dr. Cullimore will undertake more deep-ocean expeditions to shipwrecks and gas hydrates to study the rusticles, and will soon visit the Grey Lady for the fifth time.

"On the next expedition with James Cameron, we're taking a digitized, portable X-ray unit to get a look at the structure of the rusticles – they are very complicated little beasts."

Inside of rusticle



Bacterial etching of rusticle

DID YOU KNOW?

Droycon is developing a new test for coliforms that can be used by communities to monitor for safe water. This is an important test to have on hand, as coliforms and other similar microbes were the cause of recent water woes in Walkerton, Ontario, and North Battleford, Saskatchewan.

AGRICULTURE & BIOTECH

Dr. Lorne Babiuk

World Leader in Vaccine Research

Since it was established in 1975, the Vaccine and Infectious Disease Organization (VIDO) in Saskatoon has emerged as a world leader in animal vaccine research. It has developed not one, but five world firsts in new animal vaccines. In the past few years, it has expanded its research to include development of vaccines for humans.

"We have decades of experience in developing vaccines and drugs to treat veterinary diseases," explained Dr. Lorne Babiuk, chief executive officer of VIDO, which is owned by the University of Saskatchewan. "Yet, we also study human diseases. This is important because more than 75 per cent of new diseases found in humans have a link to animals."

VIDO has created five animal vaccines that are world firsts.

VIDO has assembled a team of scientists from around the world in a variety of disciplines. The research team includes medical doctors as well as bacteriologists, chemists, immunologists and veterinarians. They conduct research in a 100,000-square-foot laboratory at the university and a 160-acre research station outside of Saskatoon.

"We believe that prevention of diseases by vaccination is more cost-effective than treatment after the disease occurs," Dr. Babiuk said. "Our goal is to do world-class research in the areas of infectious disease and vaccine development that has broad benefit to society."

DID YOU KNOW?

The Vaccine and Infectious Disease Organization (VIDO) was created in 1975.

Five VIDO vaccines for livestock diseases were "world firsts."

VIDO has more than 60 patents on vaccines, and another 30 are pending.

More than 75 per cent of new diseases in humans have links to animals.

VIDO is working to develop "needle-free" vaccines that can be taken by mouth or through the nose.

VIDO was initially created to benefit Canadians, but its achievements have had an impact around the world. VIDO has registered more than 60 patents on a wide range of vaccines, with another 30 patents pending. Infectious diseases today cause a third of all deaths worldwide, and Dr. Babiuk maintains that the best defence against disease is vaccines.

The organization is a member of two national teams working to develop vaccines to prevent Severe Acute Respiratory Syndrome (SARS) and hepatitis C. The teams are also trying to develop a vaccine that can be taken through the mouth or nose rather than by needle.

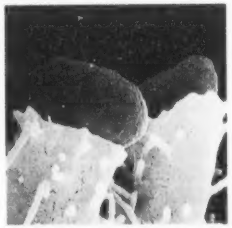
SARS, which is a severe form of pneumonia, surfaced in March 2003. Canada was the hardest-hit country outside of Asia, with 42 per cent of cases being health-care workers. Up to 170 million people worldwide may have the hepatitis C virus, which can lead to severe liver damage. If VIDO can help develop vaccines for these two infectious diseases, it may have two more world firsts under its belt that will save many lives.

VIDO also plays a key role in training young Saskatchewan scientists. "We believe that it's important to train the next generation of scientists. Nearly one-third of our staff is made up of graduate students and post-doctoral fellows," Dr. Babiuk said.

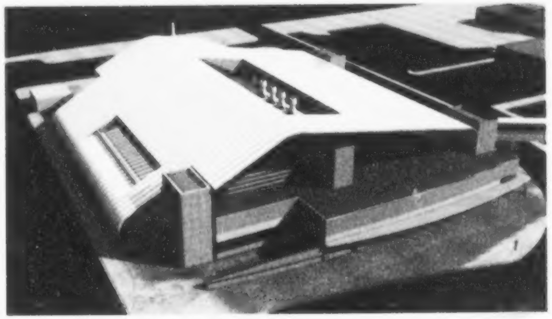
"We believe that it's important to train the next generation of scientists," said Dr. Babiuk.

"It's a pretty exciting place to be a student because you can work with a number of different scientists and learn about many different projects – and know that the work you do will be helping society."

VIDO is preparing for the future. A $19-million expansion was opened by VIDO in 2003, and there are plans to build a $62-million International Vaccine Centre. "The new centre will allow us to safely study some of the more difficult diseases, like influenza and West Nile virus," said Dr. Babiuk. This centre will be one of the largest vaccine research laboratories in North America when it is completed in 2009.



E. coli bacteria that have infected intestinal cells, causing the formation of "pedestals."



International Vaccine Centre conceptual rendering

"We all know there are always going to be new diseases," said Dr. Babiuk. "There are diseases that have been around a long time that we still can't control." Vaccine research is a critical tool in preventing these diseases.

DID YOU KNOW?

VIDO helped develop a vaccine for cattle against *E. coli* O157:H7 (the bacteria that killed seven people in Walkerton, Ontario) that is now being commercialized.

VIDO is a member of two national teams working to develop vaccines against SARS and hepatitis C.

Saskatchewan Scientists Help Develop Canola

Imagine driving through rural Saskatchewan in summer without seeing the familiar sight of waving fields of yellow-flowered canola. If it wasn't for the work of Saskatoon-based agricultural research scientist Dr. Keith Downey and several of his collaborators, canola would not have become Saskatchewan's second largest crop, after wheat.

In the 1960s and early 1970s, Dr. Downey and his team of researchers at the Agriculture and Agri-Food Canada research station in Saskatoon worked to develop a new edible oil plant from the traditional oilseed crop, rapeseed. The new crop, eventually called canola, quickly grew into one of Canada's most important grain crops and one of the world's most popular cooking oils.

"With Candle, we were able to convert the total rapeseed crop to what became known as 'canola quality,'" Dr. Downey said.

Like many scientific discoveries, the development of canola as we know it today was a slow process taking several decades and many researchers. Developing canola was definitely a team effort: Dr. Downey's team collaborated with a team of researchers at the University of Manitoba, led by Dr. Baldur Stefansson, as well as researchers from the National Research Council's Prairie Regional Laboratory in Saskatoon.

Dr. Downey and his collaborators began looking at ways to improve the nutritional value of rapeseed in the 1960s. Rapeseed oil was used primarily as a lubricant for machinery such as steam engines, as well as a base for margarines. However, it had some poor nutritional qualities that made it hard to use in food products and cooking.

Did You Know?

A canola plant produces yellow flowers which, in turn, produce seed pods.

Each canola seed is approximately 40 per cent oil.

The seeds are crushed to obtain canola oil for human consumption, and the remainder is processed into canola meal, which is used as a high-protein livestock feed.

Rapeseed oil had a different makeup than other vegetable oils, containing high levels of two fatty acids, eicosenoic and erucic acids. Not only did these acids have little nutritional value, Canadian government scientists were worried the acids would be harmful to human health. In the 1960s, Drs. Downey and Stefansson discovered low-erucic rapeseed varieties with the help of testing methods developed by the National Research Council's Saskatoon lab. Dr. Downey went on to breed two new varieties of the low-erucic rapeseed, which were adopted by Canadian farmers in the early 1970s.

With the fatty acid content problem resolved, the researchers had another problem. Oil was only one of two important products extracted from rapeseed. The other was the meal of the seed, left after the oil was extracted, that was processed into livestock feed. Although rapeseed meal had a high protein content that would be valuable in feed, it also contained a sulphur compound that had a bitter taste and was not nutritious. Before rapeseed could become a successful commercial crop, researchers had to solve the problem of how to make the meal usable as animal feed.

Dr. Keith Downey

Both Drs. Downey and Stefansson began work on breeding a rapeseed variety with this sulphur compound removed. In 1974, Dr. Stefansson, with the help of Dr. Downey's research, produced a variety that solved both problems: the oil was low in eicosenoic and erucic acids and the sulphur substance had been removed from the meal. However, this new variety could only be grown in certain areas of the southern prairies. In 1977, Dr. Downey developed a variety called Candle that could be more widely grown.

"With Candle, we were able to convert the total rapeseed crop to what became known as 'canola quality' and expand our markets in Japan and into the U.S., as well as other countries," Dr. Downey explained.

In the late 1970s, the oilseed industry registered the name canola (a combination of the words Canada and oil) and a new Canadian crop was born. Before this, 95 per cent of edible oil used in Canada had to be imported. "We turned the tables with canola, and we became a net exporter," Dr. Downey said. "Canola became the food industry's oil of choice."

"Canola became the food industry's oil of choice."

The work of Dr. Downey and his colleagues created a crop that has grown into one of the world's most popular cooking oils – ranking third behind palm and soybean oils. It's also considered one of the most healthy edible oils – with a high level of monounsaturated fat that is good for the heart and low levels of saturated fat, known to contribute to heart disease.

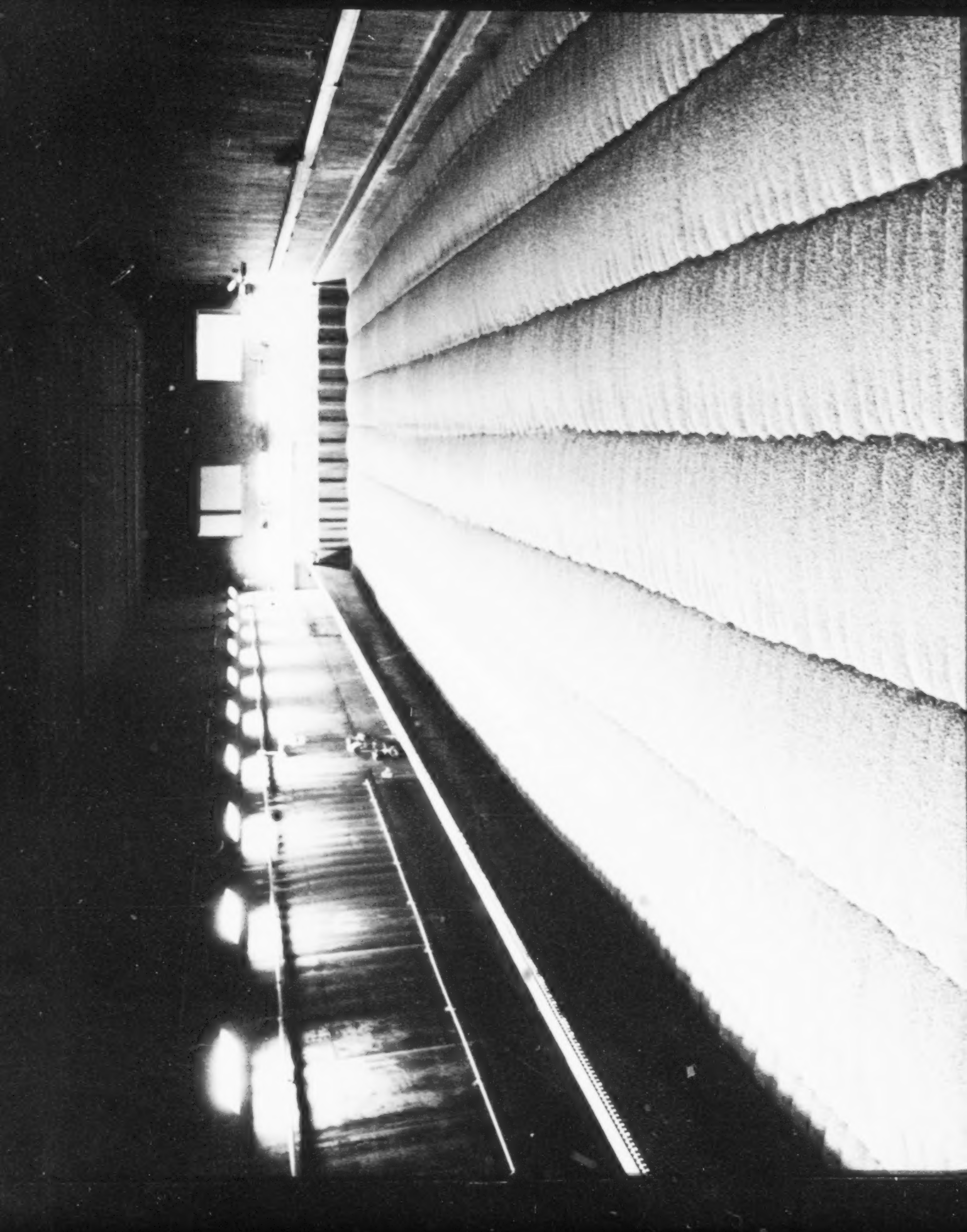
DID YOU KNOW?

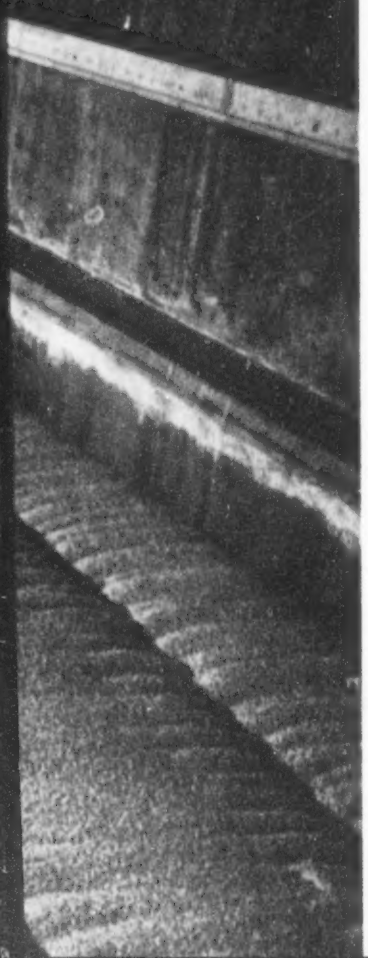
Canola oil contains the lowest level of saturated fatty acids of any vegetable oil.

Canola is high in monounsaturated fatty acids that have been shown to reduce blood cholesterol levels, and has moderate levels of essential polyunsaturated fatty acids. Canola oil is cholesterol-free.

Canadians are the largest per capita consumers of canola oil in the world.

Canola oil, with the best fatty acid profile of any edible oil, has captured 80 per cent of the salad oil market, 56 per cent of the shortening market and 42 per cent of the margarine market in Canada.





Harrington Malting Barley Brews the Best Beer

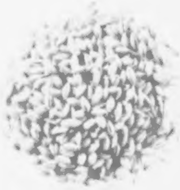
In the 1970s, plant breeders at the University of Saskatchewan's Crop Development Centre perfected a new, more versatile malting barley that has since become a favourite of brewers around the world.

Introduced in the early 1980s, Harrington malting barley quickly became the Canadian and then the international gold standard for quality in high-enzyme, two-row malting barley.

People drinking Budweiser, Bud Light or Michelob in the United States, Sapporo Black Label in Japan, Tsingtao in China, and any Canadian-brewed beer are enjoying the benefits of the research that produced Harrington malting barley.

Dr. Bryan Harvey, with the help of Dr. Brian Rossnagel, worked for several years to develop a malting barley that met the quality demands of the brewing industry and could withstand the prairie climate. When Dr. Harvey registered the final seed variety in 1981, he named it after Dr. J. B. Harrington, a former barley breeder and head of the Field Husbandry Department at the university.

"A great deal of work, skill and scientific knowledge was required to complete the job," recalled Dr. Harvey, the primary plant breeder for the project who now is a special advisor to the vice-president of research at the University of Saskatchewan.



DID YOU KNOW?

Harrington barley, a two-row malting variety bred at the University of Saskatchewan's Crop Development Centre, was licensed in 1981.

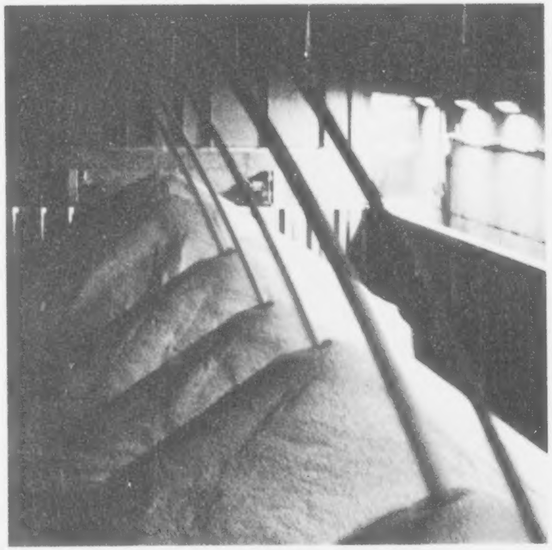
The variety is named after Dr. J. B. Harrington, a former barley breeder and head of the Field Husbandry Department at the University of Saskatchewan.

Harrington has been grown on a total of 57 million acres in Western Canada, with a single-year peak of 4.7 million acres in 1991.

It was the most dominant malting barley in Western Canada until 2002 when a newer variety, AC Metcalfe, moved into the top spot.

Producing a new variety through cross-breeding is a lengthy process. First, the research team selected two varieties they would cross to create a superior new variety: Betzes and Klages were chosen as the "parent" varieties. "What we set out to do was to combine the respective strengths in those varieties," Dr. Harvey said. "Betzes was well adapted to the harsh environment of the Canadian prairies, and Klages had greatly superior quality."

After the cross was made, the researchers spent six to eight years conducting field trials to evaluate the offspring from the cross. The objective was to select the lines of barley with the desirable traits they wanted to keep and eliminate the lines of barley with less desirable traits. This was followed by three years of registration trials before the barley was registered in 1981. The first certified seed was



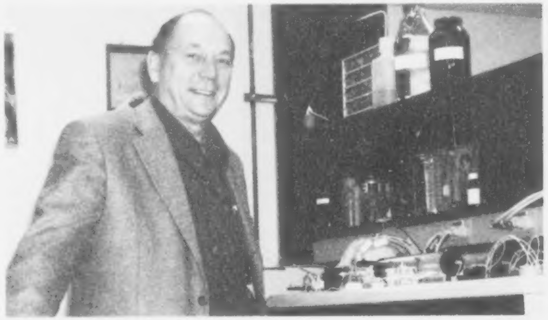
available in 1983, and by 1985, Harrington dominated commercial barley acreage. It held this top position until 2002 when it was surpassed by a new variety called AC Metcalfe.

"In the early 1980s, Harrington malting barley was considered something really new and innovative," said Erin Armstrong, president of the Brewing and Malting Barley Research Institute. "It remains a popular choice of brewers around the world today because Harrington barley is flexible enough to meet the wide range of needs of different brewers."

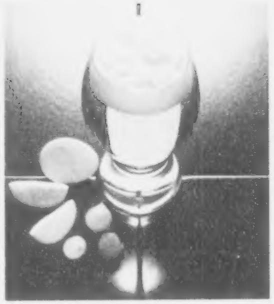
About 60 million acres of Harrington have been grown in Canada, roughly enough to seed all of the arable acres in Saskatchewan and Manitoba combined. Total Harrington production of 2.8 billion bushels over the years has an estimated value of $12.3 billion.

At its peak in the early 1990s, Harrington accounted for over half the barley acreage in Western Canada and up to 80 per cent in Saskatchewan.

Harrington also became very popular with American brewers and farmers, accounting for 40 per cent of the 2004 certified seed acreage in the United States, by far the largest variety grown.



Dr. Bryan Harvey

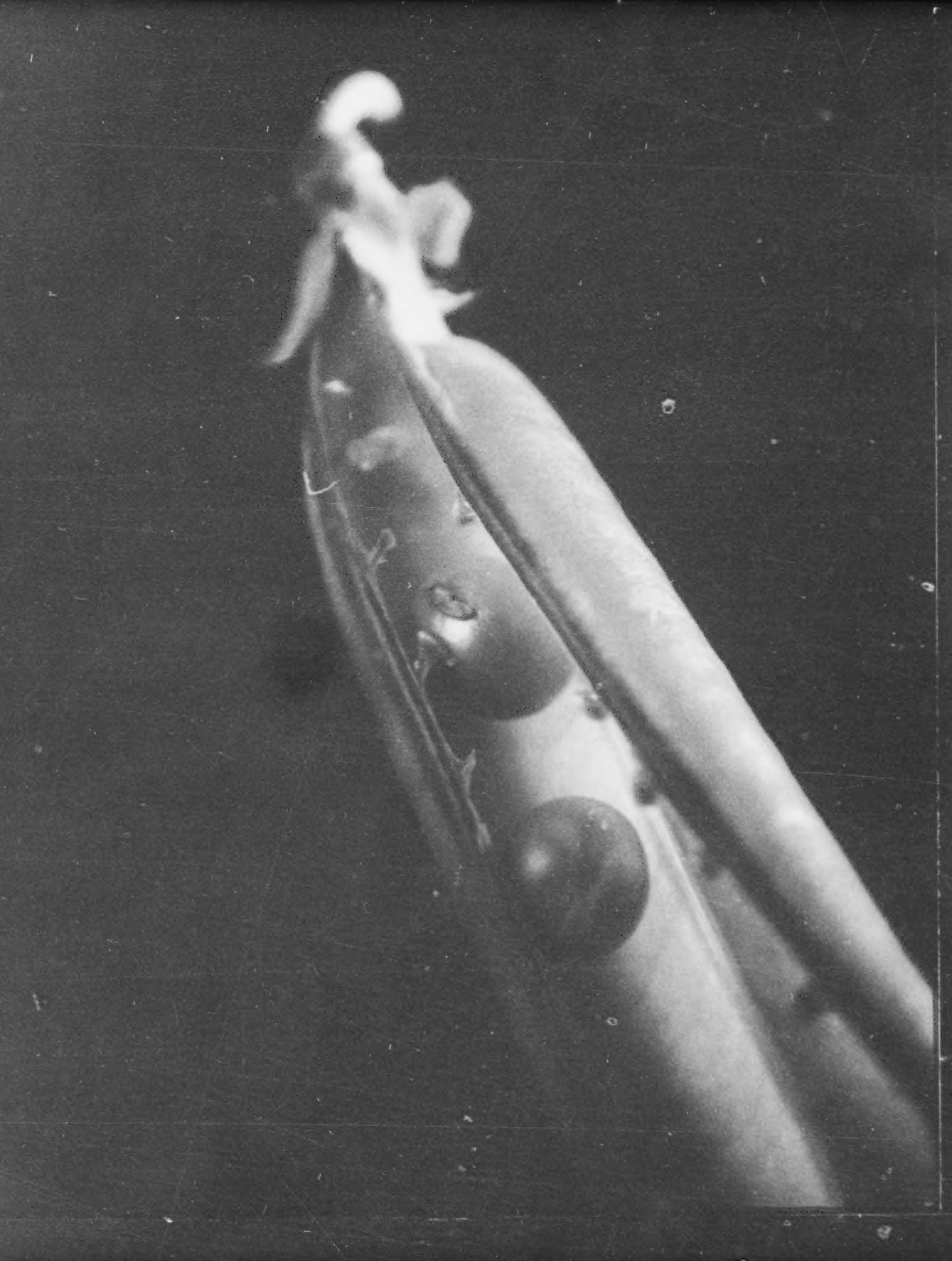


DID YOU KNOW?

Total production of Harrington barley is estimated at 61.5 million tonnes or 2.8 billion bushels, valued at $12.3 billion.

Harrington is used by brewers throughout the world because of its versatility in the malting process.

People who drink Budweiser, Bud Light or Michelob in the United States, Sapporo Black Label in Japan, Tsingtao in China, and any Canadian beer have consumed Harrington malting barley.



Pulse Crop Development Makes Huge Contribution to Agriculture

The work of Saskatchewan crop researchers has helped our province build a fledgling pulse crop industry into a world powerhouse in a matter of a few decades. Since the new pulse varieties were developed in the 1970s, Saskatchewan has become one of the world's top exporters of lentils and peas.

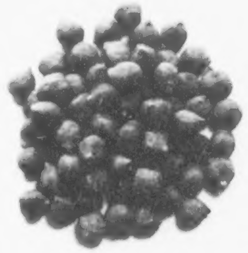
Pulse crops, such as peas, lentils, beans and chickpeas, belong to the legume family and are an important food source for much of the world because of their high protein levels.

When the international price of wheat plummeted in the early 1970s, Saskatchewan farmers turned their attention to growing specialty crops, including pulse crops, to put more money into their pockets.

"From virtually zero to over three million acres in 30 years is amazing," Dr. Slinkard said.

"Pulse production in Saskatchewan has increased dramatically, especially for peas and lentils, since the 1970s," said Garth Patterson, executive director of the Saskatchewan Pulse Growers. "For example, pea acreage has expanded from only 2,000 acres in Saskatchewan in 1970 to a record 2.6 million acres in 2004. Similarly, lentils have gone from 3,000 acres in 1970 to 1.9 million acres in 2004."

Saskatchewan now produces 97 per cent of Canada's lentils and 70 per cent of Canada's pea production. A key reason for the increased production levels was the work of research scientists at the University of Saskatchewan's Crop Development Centre.



DID YOU KNOW?

Pulses are an important source of protein, especially in developing countries. Various kinds of pulse crops provide about 10 per cent of the total dietary protein in the world. Pulses have about twice the protein content of most cereal grains such as wheat and rice.

Currently, more than 20,000 farmers in Saskatchewan grow pulse crops. Income from pulse crops accounts for 14 per cent of all Saskatchewan farm cash receipts.

More than 100 specialty crop processors in Saskatchewan employ almost 1,300 people.

Beans, peas and lentils, important pulse crops in Saskatchewan, are the most well known of the 1,800 species of the legume family.

Dr. Al Slinkard, the centre's first pulse scientist, worked there from 1972 until his retirement in 1998. Over the years, Dr. Slinkard developed 19 new pulse varieties, two of which charted the course for the development of the lentil industry in all of Western Canada. His Laird class of lentil, released in 1978, was the most widely grown and recognized lentil class in the world in the 1990s. And now the name "Laird" has been adopted internationally as the market class for large, seeded green lentils.

"When we started our research, I never dreamed that pulse crops would become such an important part of the cropping cycle and the economy in Saskatchewan," Dr. Slinkard said. "From virtually zero to over three million acres in 30 years is amazing!"

The first task the Crop Development Centre scientists tackled was how to develop adapted varieties and appropriate technology so that lentils and chickpeas could be successfully grown in central and southern Saskatchewan and peas in north-central Saskatchewan.

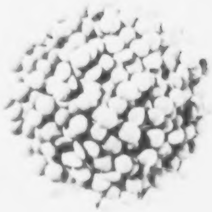
Saskatchewan now produces

97 per cent of Canada's lentils and

70 per cent of Canada's pea production.

"One of the reasons prairie farmers quickly adopted pulse crops in their cropping cycle was because they help rejuvenate the soil," Dr. Slinkard explained. As a legume, pulses fix most of their own nitrogen and, after they are harvested, leave some of this nitrogen in the soil, which helps provide nutrients to the next crop. "That meant pulse crops could replace summer fallow (the practice of cultivating the land but not planting a crop every second year). They could then get two crops off the land in two years," he added.

About 20,000 Saskatchewan farmers now grow pulse crops, which account for 14 cents of every dollar made in the agriculture sector of the provincial economy. In addition, more than 100 specialty crop processors in Saskatchewan employ almost 1,300 people.



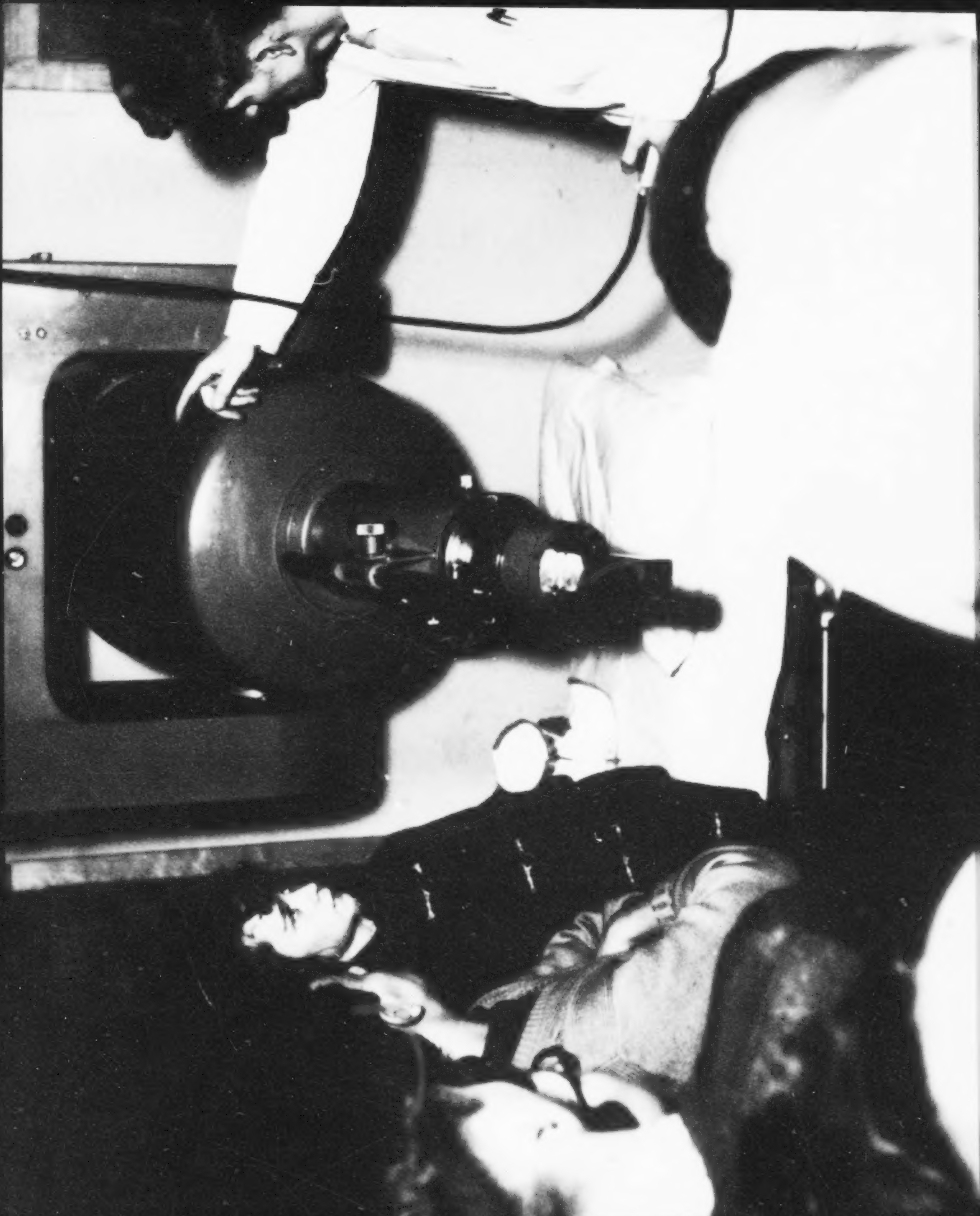
DID YOU KNOW?

Pea acreage has grown from just 2,000 in 1970 to a record 2.6 million in 2004.

Saskatchewan produces 97 per cent of the Canadian lentil crop and 70 per cent of the Canadian pea crop.

The use of pulses dates back more than 10,000 years and spans the globe.

Records of pulse use were found in the Egyptian pyramids. Dry pea seeds were discovered in a village in Switzerland dating back to the Stone Age, and some centuries-old pea seeds have been discovered in the ruins of Troy.



Pioneering Cancer Radiation Treatment

In the 1940s and 1950s, the University of Saskatchewan was a pioneer in the use of radiation for cancer treatment. In 1951, a team of researchers at the university began operating the world's first non-commercial cobalt-60 machine.

Nicknamed the "cobalt bomb," the unit was designed by physicist Dr. Harold Johns and built by John MacKay of Saskatoon. The pioneering team of researchers treated their first cancer patient in November 1951.

"It was the beginning of the use of cobalt radiation in the treatment of deep-seated cancers," recalled Dr. Sylvia Fedoruk, who was one of the four graduate students working on the project with Dr. Johns. "This was quite exciting for all of us." Dr. Fedoruk went on to lead a distinguished career in medicine before becoming Saskatchewan's Lieutenant-Governor from 1988 to 1994.

"It was the beginning of the use of cobalt radiation in the treatment of deep-seated cancers," recalled Dr. Sylvia Fedoruk.

As with many scientific firsts, there is some dispute over who actually was the first to win the cobalt-60 "race." Although the Saskatchewan group was the first to install their unit in August 1951, a medical team at the Victoria Hospital in London, Ontario, was the first to use a cobalt-60 machine to treat a patient for cancer in October 1951, beating the Saskatchewan team by one month.

DID YOU KNOW?

The cobalt-60 radiation treatment machine began operating at the University of Saskatchewan in 1951.

6,728 cancer patients received treatment with the cobalt-60 unit before it was taken out of service in 1972.

Decommissioning of the cobalt-60 unit in 1972
(left to right: Dr. H.E. Johns, Dr. C.C. Burkell, Dr. Sylvia Fedoruk)

While the London patient lived only a few weeks after treatment, the Saskatchewan patient, Molly Birtsch, a 43-year-old mother of four, successfully fought her cancer and went on to live many years after.

"The machine was actually quite easy to operate," explained Dr. Fedoruk. "Because of the intense radiation generated from the cobalt-60, the machine was very good for treating deep-seated tumours in the bladder, cervix and lungs."

The University of Saskatchewan's leadership in cancer radiation research started much earlier than the installation of the cobalt-60 unit. In fact, in the post-World War II era, the university's physics department was at the forefront of nuclear physics in Canada.

As a result of this reputation, the University of Saskatchewan received Canada's first betatron in 1948. The betatron used magnets to accelerate electrons, creating energy levels of up to 25 million electron volts. This created powerful X-rays that could be used in cancer radiation treatment, although the machine's operating costs made large-scale treatment of cancer patients

Demonstration of the cobalt-60 unit

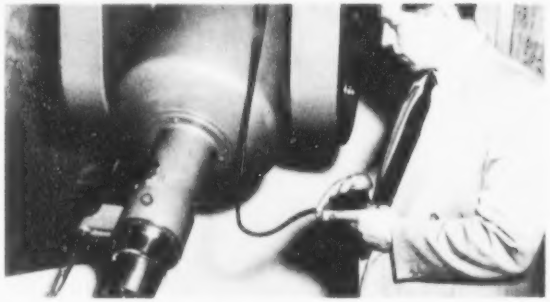
impractical. As well, the strength of the radiation produced by the betatron often wasn't enough to attack deep-seated cancer in the body.

The university acquired a better tool with the cobalt-60 unit. The radioactive material used in the machine was produced at Canada's first nuclear reactor in Chalk River, Ontario.

The unit was used to treat 6,728 patients during its 21 years of service before being replaced by a machine designed by Atomic Energy of Canada Ltd.

With Dr. Johns's cobalt-60 machine, scientists made advances in other research, including the areas of radiological physics, radiation chemistry, and the effects of high-energy radiation on plants and animals.

As a result of his work, Canada became a pioneer in the field of therapeutic radiology. Millions of people around the world have been helped by cobalt-60 therapy and techniques pioneered in Saskatoon.

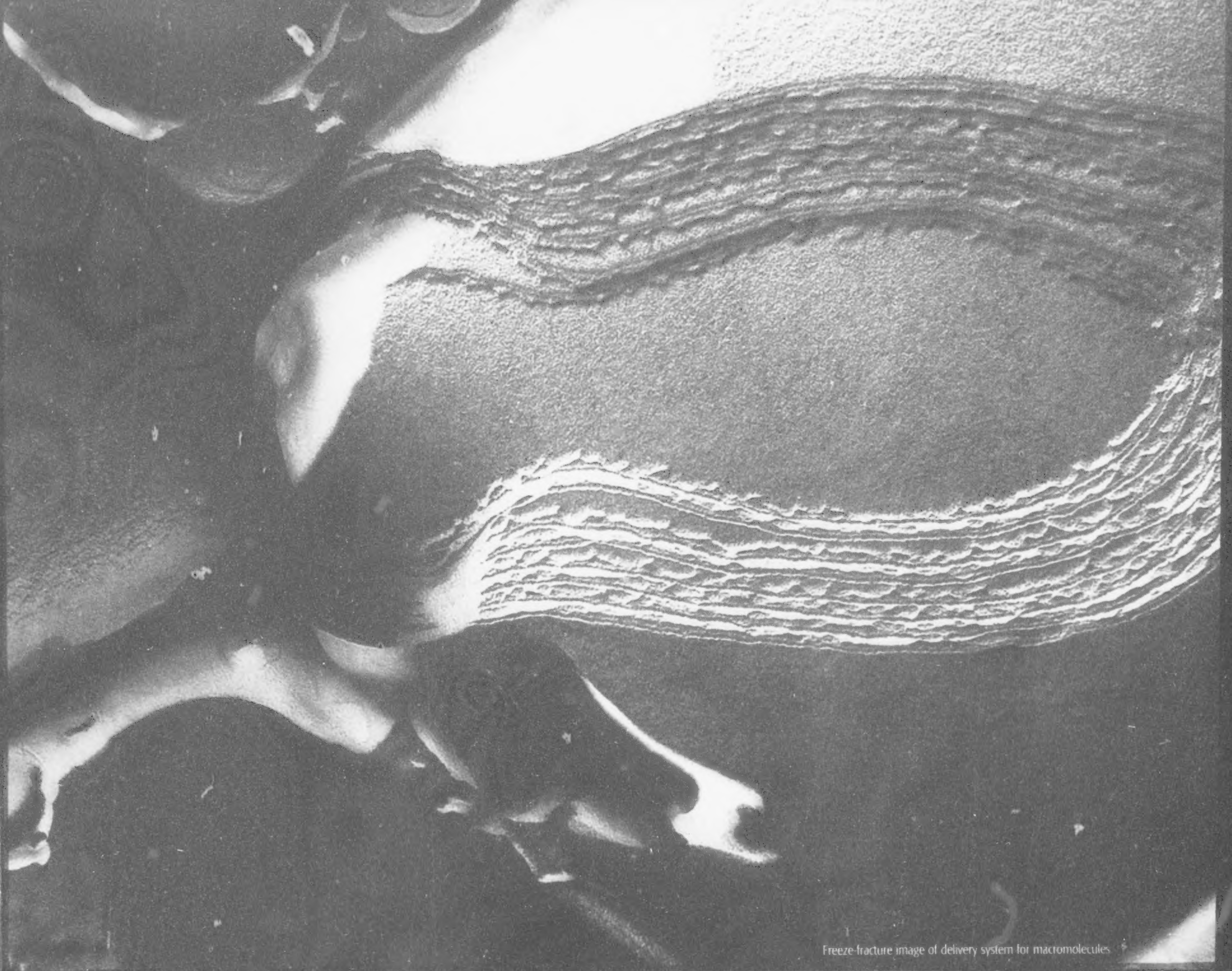


Dr. Harold Johns with the cobalt unit

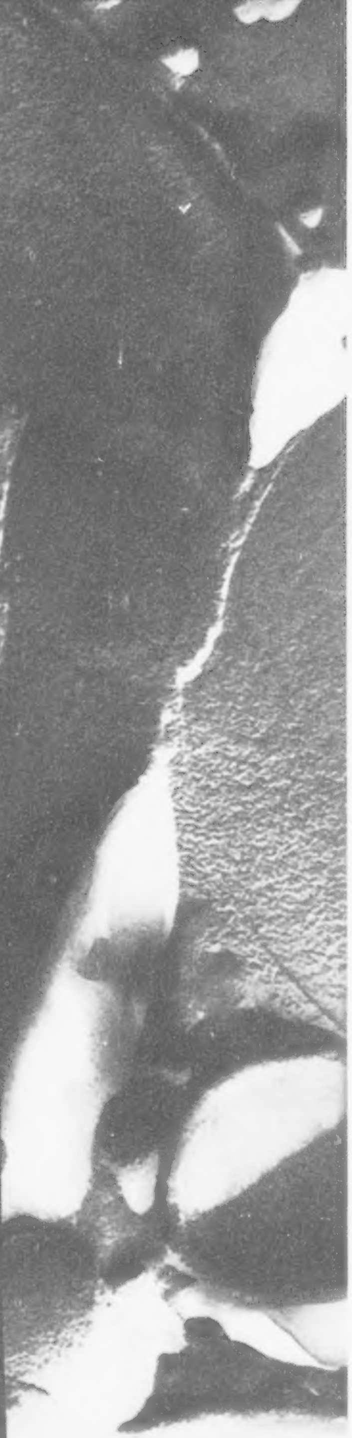
DID YOU KNOW?

Cancers deeply seated in the bladder, cervix and lungs could be successfully treated with radiation generated by the cobalt-60 machine.

Canada became recognized as a world leader in nuclear medicine in part because of the work done by the Dr. Harold Johns and his team in Saskatoon.



Freeze-fracture image of delivery system for macromolecules



Delivering Medicine Through the Skin Without Needles

A University of Saskatchewan scientist has invented a technology that may eventually replace needles for delivering certain types of medication through the skin.

Needles are now used by health professionals and patients themselves to inject large protein and gene molecules into the bloodstream. This can be particularly painful for diabetic patients, for example, who require numerous daily injections of insulin over the course of their lifetime.

"We believe this technology has the potential to make an enormous contribution in enhancing the quality of life of many patients."

Dr. Marianna Foldvari, a pharmaceutical scientist and professor in the university's College of Pharmacy and Nutrition, has developed a unique through-the-skin delivery system that could replace needles in administering proteins and genes – the pharmaceutical drugs of the future.

"The main function of the skin is to provide us with protection from external elements," she explained. "Therefore, the natural barrier function of the skin prevents even therapeutic agents from passing through it."

That's why Dr. Foldvari and her team developed a technology called Biphasix™, using "biphasic vesicles." These vesicles act as microscopic containers to carry large protein molecules through the skin, without the need for injections or any electrical device. The medication can be applied as a patch or spread on the skin as an ointment.

DID YOU KNOW?

Dr. Marianna Foldvari and her team at the College of Pharmacy and Nutrition at the University of Saskatchewan developed a new technology called Biphasix™ that can transport large molecules through the skin.

The main function of the skin is to provide us with protection from external elements. This effective barrier even prevents therapeutic agents from passing through the skin into our body.

Biphasix™ works because it creates a pathway through the surface of the skin into the deeper skin layers where the therapeutic agents can enter the blood circulation.

"We have engineered biphasic vesicles or very small organic sacs in which the therapeutic protein and genes can be trapped," she said. "When applied to the skin, the vesicles create a pathway to help them penetrate further into the deeper skin layers. Once inside, the vesicles release their content and the therapeutic agent can interact with the cells to provide its effect."

Dr. Foldvari created PharmaDerm Laboratories Ltd. in 1991 to commercialize the technology by evaluating it in a series of clinical trials. These trials are necessary before federal regulatory agencies will approve the technology for use on patients. Helix BioPharma Corporation, an Ontario company that specializes in pharmaceutical product development and marketing, acquired PharmaDerm in 1999.

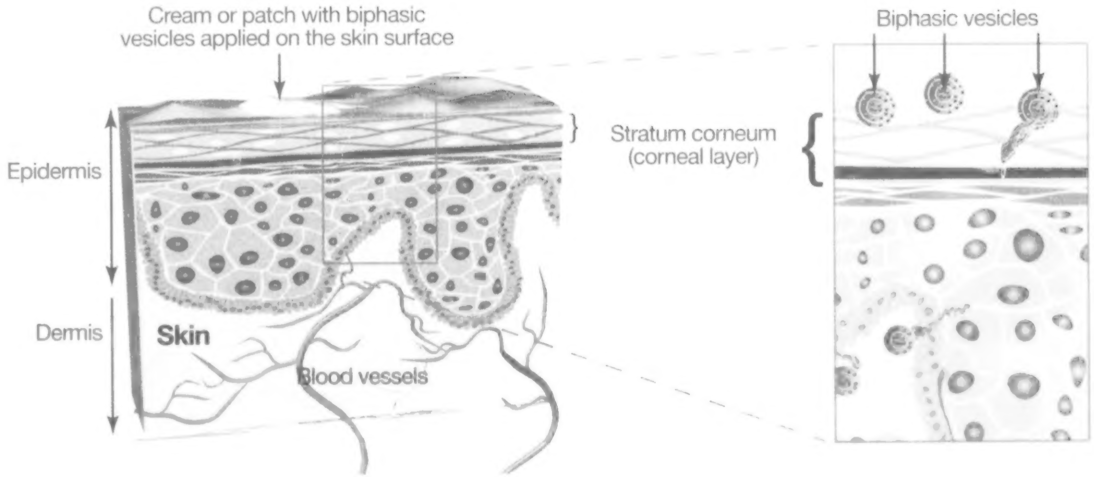
"We believe this technology has the potential to make an enormous contribution in enhancing the quality of life of many patients and in eliminating the need for numerous injections," Dr. Foldvari said.

"There may even be other benefits such as improved targeting to specific sites in the body, which would prevent side effects of medicines and reduce the frequency of drug administrations. For example, a patch could supply medicine for one to four weeks at a time."

Dr. Marianna Foldvari

PharmaDerm Laboratories Ltd., backed by Helix BioPharma, is currently developing three products using Biphasix™ technology: an interferon-alpha cream for the treatment of topical viral infections such as genital warts and cervical cancer; an insulin patch for the treatment of diabetes; and a vaccine delivery system.

Drug delivery is the fastest growing segment of the pharmaceutical industry, with some analysts predicting that sales could top $50 billion (US) within a few years.



DID YOU KNOW?

One square centimetre of skin contains three million cells, 100 sweat glands, 12 nerves, 10 hair follicles and three blood vessels.

People who could benefit from this technology include diabetics who require numerous daily injections over a lifetime and those with hepatitis C who may receive dozens of injections daily.

Research Proves Ovulation Can Occur at Almost Any Point in Monthly Cycle

Conventional wisdom about the female menstrual cycle and when a woman is able to reproduce was turned upside down in 2003 with the release of a study by a research team at the University of Saskatchewan.

The team, led by Dr. Roger Pierson, discovered there is more than one "wave" or peak period during the menstrual cycle when the follicles in a woman's ovaries prepare themselves to release an egg. Dr. Pierson's research showed that women can have two or three such peak waves per cycle. During one of these peaks, one follicle will become dominant and release an egg that could be fertilized and result in pregnancy.

This means a woman can become pregnant at any time during her menstrual cycle, depending on the timing of these waves and which one leads to the development of a mature follicle and release of an egg. Previously, medical experts believed there was only one such wave during the 28-day menstrual cycle, resulting in an egg ready for fertilization on about day 14 of the cycle.

"The study shows that we have not fully understood the basic biological processes that occur during menstrual cycles. We are literally going to have to rewrite medical textbooks," Dr. Pierson said.

The discovery has major implications in the field of reproductive research both in helping women who have difficulties in conceiving and in preventing unwanted pregnancies. Discover magazine ranked the results among the top 100 science stories of 2003. As well, Dr. Pierson, who is the head of the university's Reproductive Biology Research Unit, received the 2003 Women's Health Hero Award from Chatelaine magazine for the research work.

DID YOU KNOW?

In the past, doctors and research scientists had thought that ovarian follicles prepared themselves to produce a viable egg only once during a menstrual cycle. Dr. Pierson's team discovered that women can have two or three waves of follicular development during their monthly cycle.

For a six-week period, the team performed ultrasound tests on 63 women, ages 18 to 40, who had normal menstrual cycles. The results provided a more complete picture of a woman's monthly ovarian cycle than previous studies.

Dr. Roger Pierson

In their ground-breaking study, the University of Saskatchewan researchers performed ultrasound imaging on a group of 63 women, who ranged in age from 18 to 40, every day for six weeks. Thanks to the intensive research work and commitment of the women volunteers, the researchers obtained a more complete picture of activities in a woman's ovaries over a full menstrual cycle than ever before.

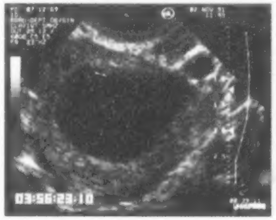
Key contributors to the research included Dr. Angela Baerwald, a University of Saskatchewan doctoral student, and Dr. Gregg Adams, a veterinarian and professor with the university's Western College of Veterinary Medicine. Dr. Adams and Dr. Pierson had previously collaborated on similar research with cows and horses and discovered that these animals also had more than one wave of follicle development in their reproductive cycles.

Dr. Pierson said up to 40 per cent of women may not be able to use traditional natural family planning methods because they could be fertile at almost anytime during their menstrual cycle – instead of around Day 14. The researchers found that some women ovulate as late as Day 21 of their cycle.

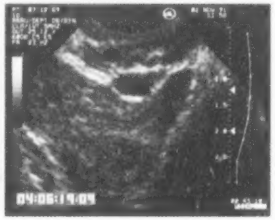
"We are literally going to have to rewrite medical textbooks," Dr. Pierson said.

"These findings might explain a number of the mysteries about pregnancy, including why the traditional rhythm method is not an effective form of birth control and why oral contraceptives don't work for some women."

Some birth control pills deliver high levels of hormones around Day 14 and taper off near the end of the cycle, which could lead to pregnancy if ovulation occurs at the end of the cycle. As well, some forms of assisted reproductive technologies to help women conceive may not be as effective if they depend on the old model of one possible window for ovulation.



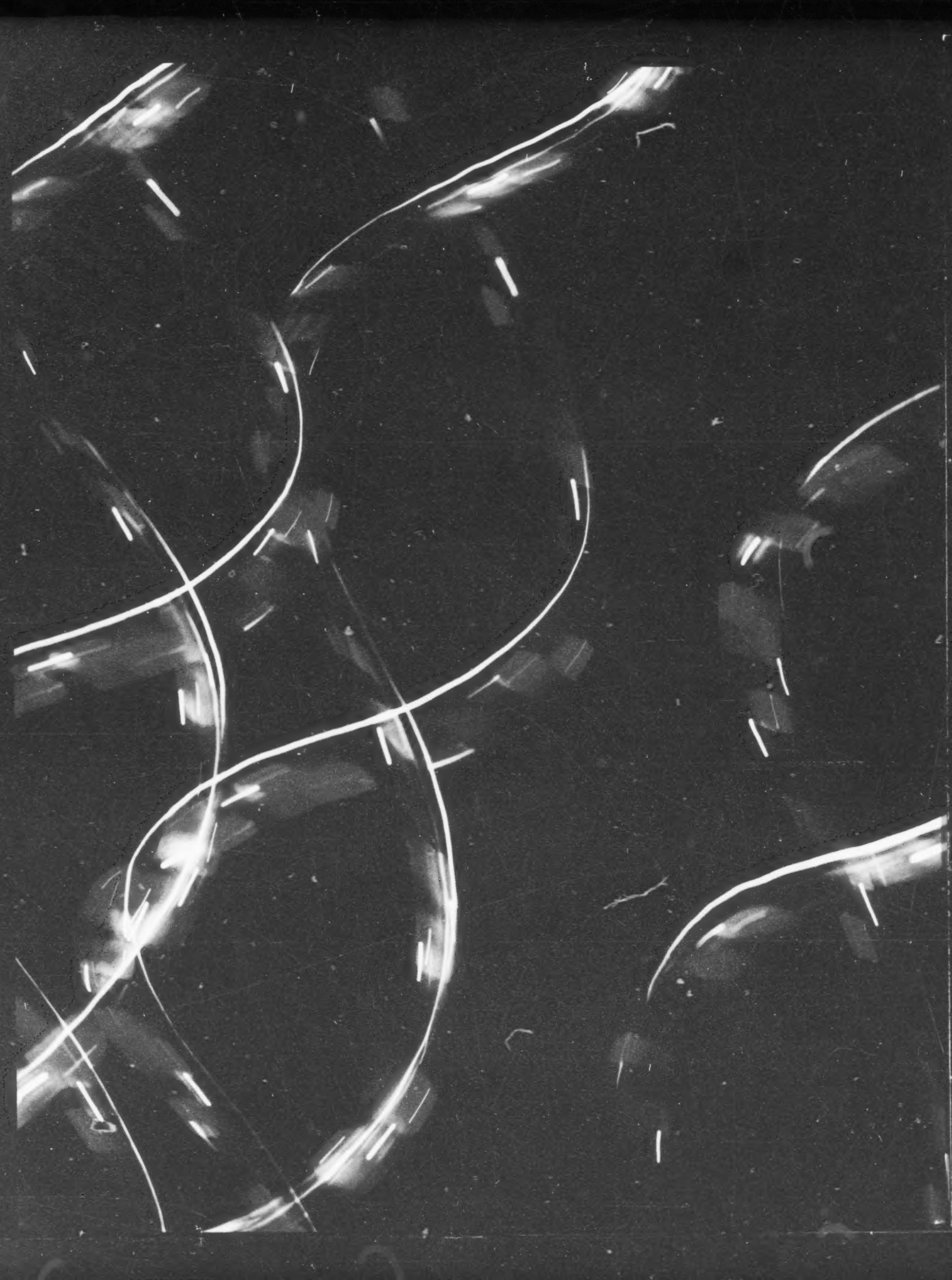
Preovulatory follicle



Postovulatory follicle

DID YOU KNOW?

Dr. Roger Pierson was awarded the 2003 Women's Health Hero Award from Chatelaine magazine for his follicle wave research, and Discover magazine included the work in the Top 100 Science Stories of 2003.



Electrifying DNA

Biology and electronics are two disciplines of science most people don't think about in the same breath. Yet a new molecule developed by biochemist Dr. Jeremy Lee and colleague Dr. Palok Aich at the University of Saskatchewan combines both sciences. The molecule – called M-DNA – conducts electricity.

"In very simple terms, I took ordinary DNA and converted it into a good conductor of electricity," Dr. Lee said. "The new DNA is called M-DNA because it contains a metal ion." Conducting metal ions such as zinc, cobalt or nickel are inserted into the centre of the DNA helix, creating an effective wire-like conductor that is only one molecule thick.

At about two nanometres, or two billionths of a metre across, [M-DNA] is the thinnest wire ever produced.

M-DNA is very, very small. At about two nanometres, or two billionths of a metre across, it is the thinnest wire ever produced. To give you an idea of how small this is, consider a human hair is about 10,000 nanometres thick.

Potential applications in electronics, medical research, and the emerging field of nanotechnology are tremendous. "We now are developing methods for the manufacture of biosensors and electronic circuits made out of M-DNA," Dr. Lee explained.

DID YOU KNOW?

M-DNA was invented by Dr. Jeremy Lee, a University of Saskatchewan biochemist, with the help of Dr. Palok Aich.

M-DNA is a marriage of molecular biology and electronics.

Conducting metal ions such as zinc, cobalt or nickel are inserted into the centre of a DNA helix to create a semi-conductor that is only one molecule or roughly two nanometres thick.

"One of the difficulties of making anything very small is that typically you require a very small machine to make it," he said. "The same is true of electronics, and this is one of the reasons that some scientists think we have reached the limit of miniaturization."

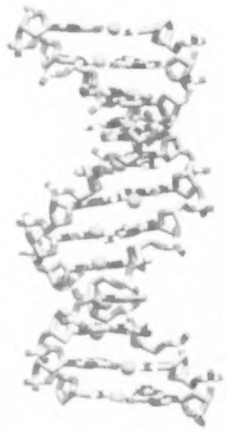
However, the beauty of M-DNA is that it self-assembles. For example, Dr. Lee and his team have made a simple transistor by self-assembly that is only 10 nanometres thick.

The first patent on the discovery was filed in 1997. Five years later, Dr. Lee created a company called Adnavance, with the help of University Medical Discoveries Inc., a Toronto-based technology development company, to market the revolutionary technology.

Dr. Jeremy Lee

"These tiny and speedier circuits could potentially become the building blocks for bio-electric circuits and eventually replace the smallest of silicon microchips that drive the world's information technology industry," Dr. Lee said.

M-DNA could also pave the way for highly sensitive new biosensors that help reduce adverse drug reactions, improve diagnosis of disease, predict the outcome of disease and reduce the cost of drug development.



Biosensors are detection devices that can translate biological events into optical, electronic or other signals. In addition to medicine, M-DNA has possible applications in areas such as environmental monitoring, security and national defence.

The markets for M-DNA product applications are substantial and growing. For example, the molecular diagnostics market is expected to more than double to $5.2 billion (US) in the next four years.

DID YOU KNOW?

A nanometre is one billionth of a metre.

A human hair is about 10,000 nanometres thick.

BRAEBON
BRAEBON

Helping People with Chronic Pain

Living with chronic pain due to an injury or other health condition can be a tremendous burden. However, thanks to internationally recognized research being conducted at the University of Regina, people with chronic pain are learning not to let the fear of that pain rule their lives or even make the pain worse.

Dr. Gord Asmundson first noticed the effects of fear of pain on people with chronic pain when he came to Regina 11 years ago. He was working as research director at the Wascana Rehabilitation Centre, where a large number of patients deal with chronic pain. There he observed that those patients who were fearful or anxious about their pain seemed almost to be worse off – as though worrying about the pain caused more pain itself. He set out to determine whether worrying about pain influenced the patients' thoughts and behaviours, which in turn delayed their recovery.

Dr. Asmundson has become one of the world's leading experts on the effects of fear on those suffering from chronic pain.

"We started with informal observations and progressed to surveys in which we asked patients about their pain, certain personal characteristics, and things that made them fearful or anxious. Then we did statistical analyses to see if a person's attitudes and behaviours were related in any way to the duration and severity of his or her pain, and we found they were."

DID YOU KNOW?

- 18 per cent of Canadian people suffer from chronic pain, and of those 18 per cent, many are disabled by the pain in some way.
- The cost of chronic pain to society exceeds billions of dollars every year in lost productivity.
- The Canadian government is providing increasing levels of funding for health care research such as theories required to understand and treat chronic pain.

The simple surveys have since progressed into an 11-year body of work that is still ongoing. During this time, Dr. Asmundson has become one of the world's leading experts on the effects of fear on those suffering from chronic pain. He is now a professor with the Faculty of Kinesiology and Health Studies at the University of Regina, where he has established the Anxiety and Illness Behaviours Laboratory to continue his research.

Once the connection was made between fear and chronic pain, Dr. Asmundson and his colleagues were able to start working on treatment methods. Treatment involves innovative approaches based on traditional methods that are meant to heal both the body and the mind.

"It's a combination of the standard approach of graded activity – an increase of activity gradually following an injury – combined with cognitive behaviour therapy that targets fears. The fears are usually 'It hurts so badly that something horrific must be wrong,' or 'I can't do that – I'll re-injure myself.' It's similar to treating a fear of flying or fear of spiders with graded exposure. Slowly, in a safe environment, you get people to do the feared activity and show them that their fears are not logical. The fear is real but not rational."

Although he has not yet completed the long-term analyses of the success of these treatment methods, preliminary results show that the methods are helping to speed up the recovery process.

More recently, Dr. Asmundson and his team of graduate students have broadened their research to include the link between post-traumatic stress disorder and chronic pain, as well as the effects of fear of pain in healthy people who do not suffer from a chronic condition.

"We are finding those with no chronic pain but who have a high fear of pain tend to respond differently from those who don't fear pain. But it's still too early to identify how this will affect their long-term health," he said.

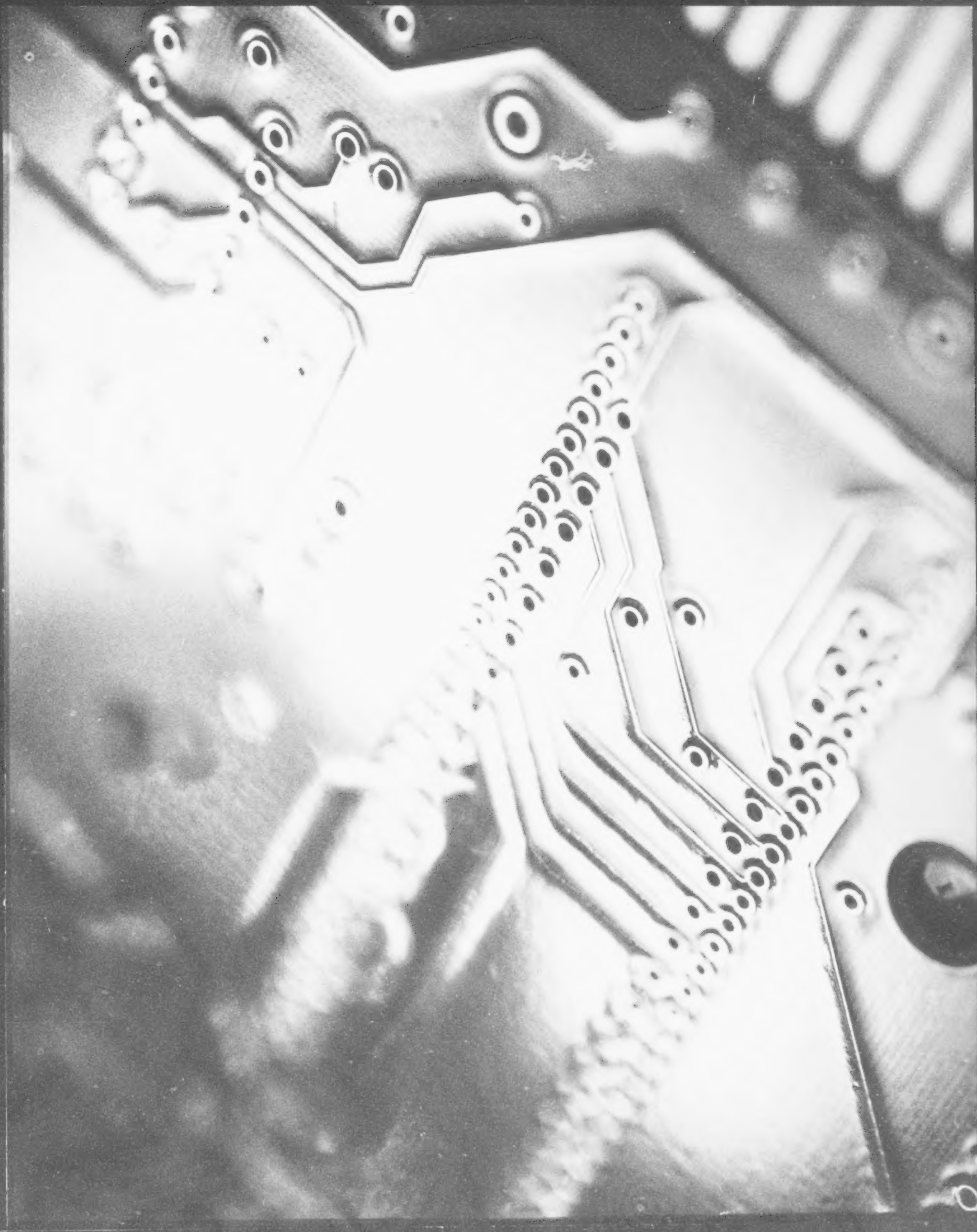
Dr. Asmundson finds his work to be rewarding in a number of ways. "This field is closely linked to medicine. This type of career, doing health research, involves thinking about health and how the body works. It's really exciting, rewarding and, if you're interested, it's about making a contribution that can help improve the human condition."

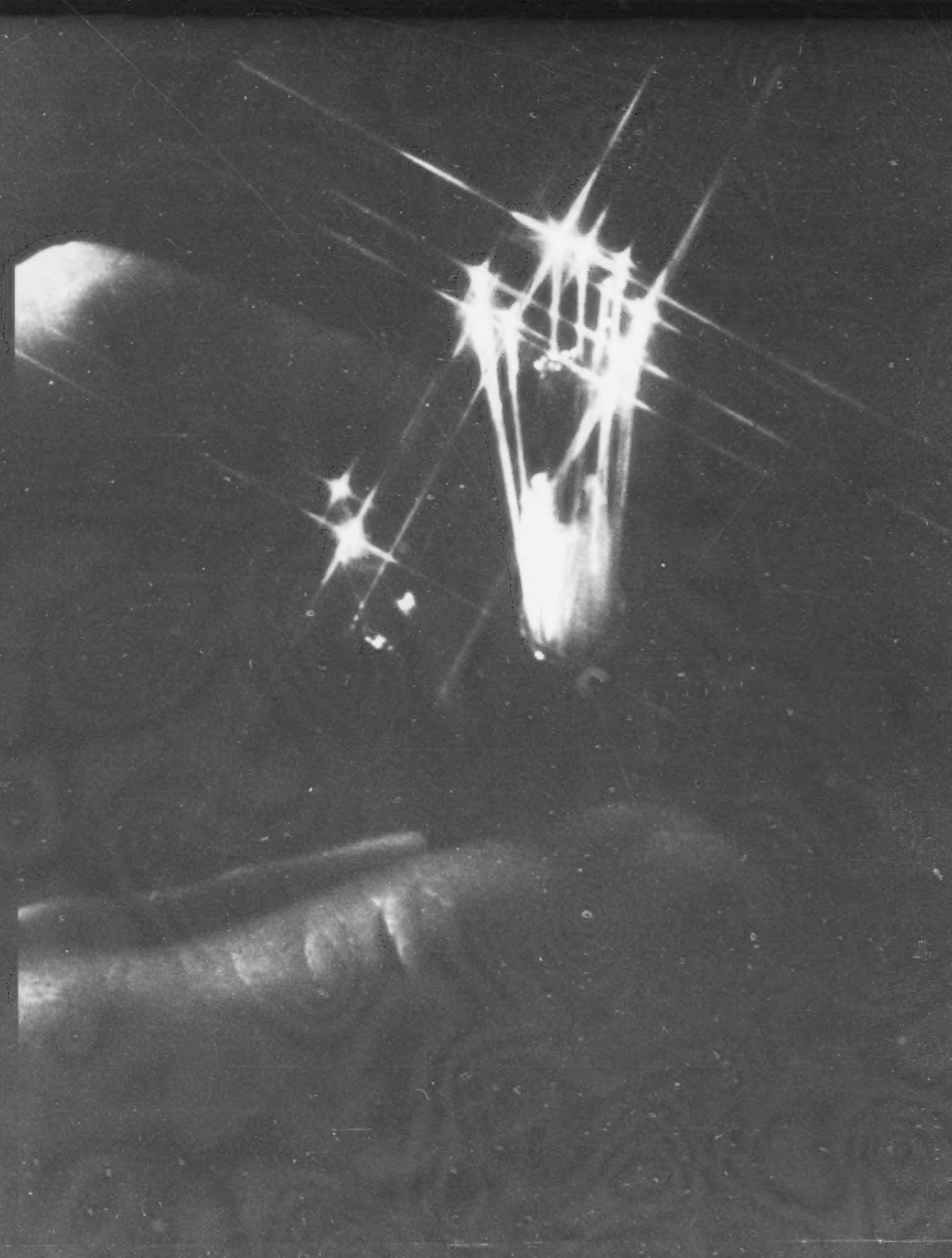
He also finds it inspiring to work with the young graduate students who are currently research assistants in his lab. "I help other aspiring scientists through mentoring and training, and I'm training grad students who will basically one day take my place."

DID YOU KNOW?

- Canadian researchers are considered leaders in the field of chronic pain.
- Although 70 studies have already been done, Dr. Asmundson estimates there are thousands more to go before the challenge of chronic pain is "solved."

IT
& TELECOMMUNICATIONS





SaskTel Installs World's Longest Fibre-Optics Network

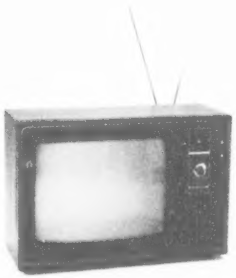
This is the story of how a small telecommunications company blazed a trail ahead of the world's telecommunications giants to become the first to develop and operate a large-scale fibre-optics network in the early 1980s.

When SaskTel first started building the network in 1980, the longest network in the world was less than 10 kilometres. By the time the Saskatchewan Crown corporation completed its work in 1984, it had installed the world's longest fibre-optics network – covering an amazing 3,268 kilometres to link 52 communities.

The project was started to help SaskTel keep ahead of rapid advances in telecommunications technology. In the late 1970s, SaskTel business managers and engineers foresaw the coming digital revolution, when most of the world's information would be communicated digitally from computer to computer.

"Our dream was to digitize the province," explained Graham Bradley, who was part of SaskTel's original fibre-optics team and went on to become director of the research and development group before retiring in 2000. "Today, this means that people in small-town Saskatchewan have better telecommunications services than people in many large American cities."

Bradley's team began researching fibre optics in the late 1970s. What they saw was a technology that allowed voice, video and data to be carried on the same fibre, with a transmission capacity far greater than any other communications medium.



DID YOU KNOW?

SaskTel completed the world's longest commercial fibre-optics network in 1984, covering 3,268 kilometres to link 52 communities in Saskatchewan.

Fibre optics is the science of communicating with laser-generated impulses of light on hair-thin filaments of glass.

A test of the fibre-optics technology established a two-way video link between Regina and Yorkton in 1981.

"Fibre optics is the science of communicating with laser-generated pulses of light travelling through hair-thin filaments of glass," said Bradley. "This digital system was much superior to the analog system then in use in terms of capacity and quality of transmission over distances."

There were three technology trends driving SaskTel to consider replacing the old analog telephone cable network with fibre optics. First, cable television was beginning to make inroads into the television market, and more consumers were asking for cable. The Government of Saskatchewan and SaskTel wanted to ensure there was a comprehensive cable network that could transmit video images throughout the province. Second, the team wanted a network that could transmit high volumes of data in anticipation of the rapid growth of computer-to-computer communication. Today, that communication has evolved into the worldwide Internet. Third, the team wanted to develop a telecommunications system that could transmit over long distances without losing quality of voice, video or data.

Today, one fibre could possibly handle one million calls.

Fibre optics fulfilled all three needs at once. At that time, one hair-thin fibre was enough to transmit 672 telephone calls or one video channel. Since the early 1980s, the capacity of fibre optics has increased tremendously to the point where, today, one fibre could possibly handle one million calls.

The conversion to fibre optics made even more sense after SaskTel decided in the late 1970s to replace its old telephone switches with digital computer ones. Fibre optics was the perfect digital carrier between these digital "hubs" or switches. The plan for a provincewide fibre-optics network was approved in 1980, and Bradley's team began installing the first 200-kilometre fibre-optics cable between

Regina and Yorkton, primarily for use in transmitting video. From there, they were ready to tackle the whole network.

The Government of Saskatchewan convinced Northern Telecom Corporation to build a plant in Saskatoon to manufacture the fibre-optics cable and other electronic components. The SaskTel engineers mapped out a plan for how the network would operate. Bradley said that mostly home-grown technical talent was used. Construction crews plowed trenches for the cable in registered easements, usually next to railway lines.

Although the initial network was completed in 1984, it has been expanded many times since then to reach hundreds of communities across Saskatchewan. As well, gradually the fibre optics in the entire original network were replaced by newer fibre optics able to carry greater volumes and maintain transmission quality over longer distances.

That original decision to convert to fibre optics led to many technology advances and economic benefits in the decades to come. Recognizing the market value of its fibre-optics expertise, SaskTel created an international subsidiary to market the corporation's telecommunications consulting services to global markets. SaskTel International has helped develop fibre-optics networks around the world. In fact, the subsidiary was one of the main consultants that commissioned the fibre-optics system in the Channel Tunnel connecting England to France, which was built in the 1990s.

"Without fibre optics, there would be no high-speed Internet," Bradley added.
Now Saskatchewan has one of the most comprehensive high-speed Internet networks in North America.

SaskTel became famous in the telecommunications industry because of these accomplishments, said Bradley. "Our work is known better internationally than here in Saskatchewan or even in Canada," he added.
Along with that recognition came the secret satisfaction of having beat the giants such as Bell Canada in the digital telecommunications race.

DID YOU KNOW?

SaskTel International was formed in 1986 to market the corporation's expertise, especially in fibre optics, to clients all around the world.

Pick-and-play, video-on-demand technology was pioneered by SaskTel in 1988.

ABC
GZ
GHI
PRS

Saskatchewan Credit Unions Install First Automated Tellers

How did we survive before the debit card was invented and we could purchase pizza, new clothes or a movie ticket with a swipe of a card? In Canada, we have the Saskatchewan credit union system to thank for conducting the first debit card transaction, as well as installing the first Automated Teller Machines.

The first true debit card was piloted in 1985 by credit unions in the Swift Current area.

Sherwood Credit Union introduced its first Automated Teller Machine (ATM) in 1977. Today, a network of more than 36,000 automated teller machines has extended across the country from coast to coast.

Sherwood, which has since changed its name to Conexus Credit Union, worked with Co-operators Data Services (now called CGI), Credit Union Electronic Transaction Services, and Credit Union Central of Saskatchewan to create the ATM system. Ed Gebert, who was then vice-president of finance for the Sherwood Credit Union, is widely credited with developing and promoting the ATM project within the credit union system.

"I was certain that ATMs would become popular in Saskatchewan, particularly with young people," Gebert recalled. "It was a matter, first, of training our members how to use ATMs. This younger age-group would basically grow up within our system."

Initially, the ATMs at the Sherwood Credit Union's two branches on Albert Street in Regina provided service 18 hours a day, seven days a week, with a maximum withdrawal of $200. Gebert said that until the ATMs popped up across the province, it wasn't uncommon for people to carry hundreds of dollars in cash to pay their regular bills.

DID YOU KNOW?

Automated Teller Machines were first introduced in Canada by the Sherwood Credit Union in 1977.

The first ATMs were located in the Sherwood Credit Union's branches in Regina.

The first debit cards in Canada allowed credit union members to pay for purchases at 28 Pioneer Co-op locations in the Swift Current area.

"When we set up the ATM program and credit unions added the machines at their locations, any member with a credit union member card could access the ATMs and obtain cash," he explained. "Their accounts at the local credit unions would automatically be updated at the time of the transaction."

"ATMs, at first, were only accessible 18 hours a day, but in very short order we introduced real-time banking and ATMs were available 24 hours a day, seven days a week," Gebert said. "Members could also make deposits at ATMs."

Creating a debit card for use by the credit union members was a byproduct of launching ATMs, he said.

"What happened was that as our members became more comfortable using the ATM machines, they started demanding the ability to buy products and services from merchants the same way," Gebert said.

The MasterCard payment card, a forerunner of today's debit card, was introduced to Canadians by Saskatchewan credit unions in 1982. Called

MasterCard II, the plastic card allowed credit union members to pay for purchases directly at the point of sale without running up credit card interest charges.

Now called the Global Payment MasterCard, the credit unions' card can be used at 14 million locations around the world.

The first true debit card was piloted in 1985 by credit unions in the Swift Current area and involved the installation of a point-of-sale system at 28 Pioneer Co-op outlets. The one-year trial was successful, but credit union members demanded cards that could be used with merchants in addition to just the Pioneer Co-op.

At about the same time, the Interac Association was being formed to promote the concept of sharing access to ATMs among various financial institutions to allow people to access their money more readily across the country. The financial services industry soon recognized that the Interac network could be improved if merchant terminals were included as well. That concept led to the introduction of debit cards in the early 1990s.

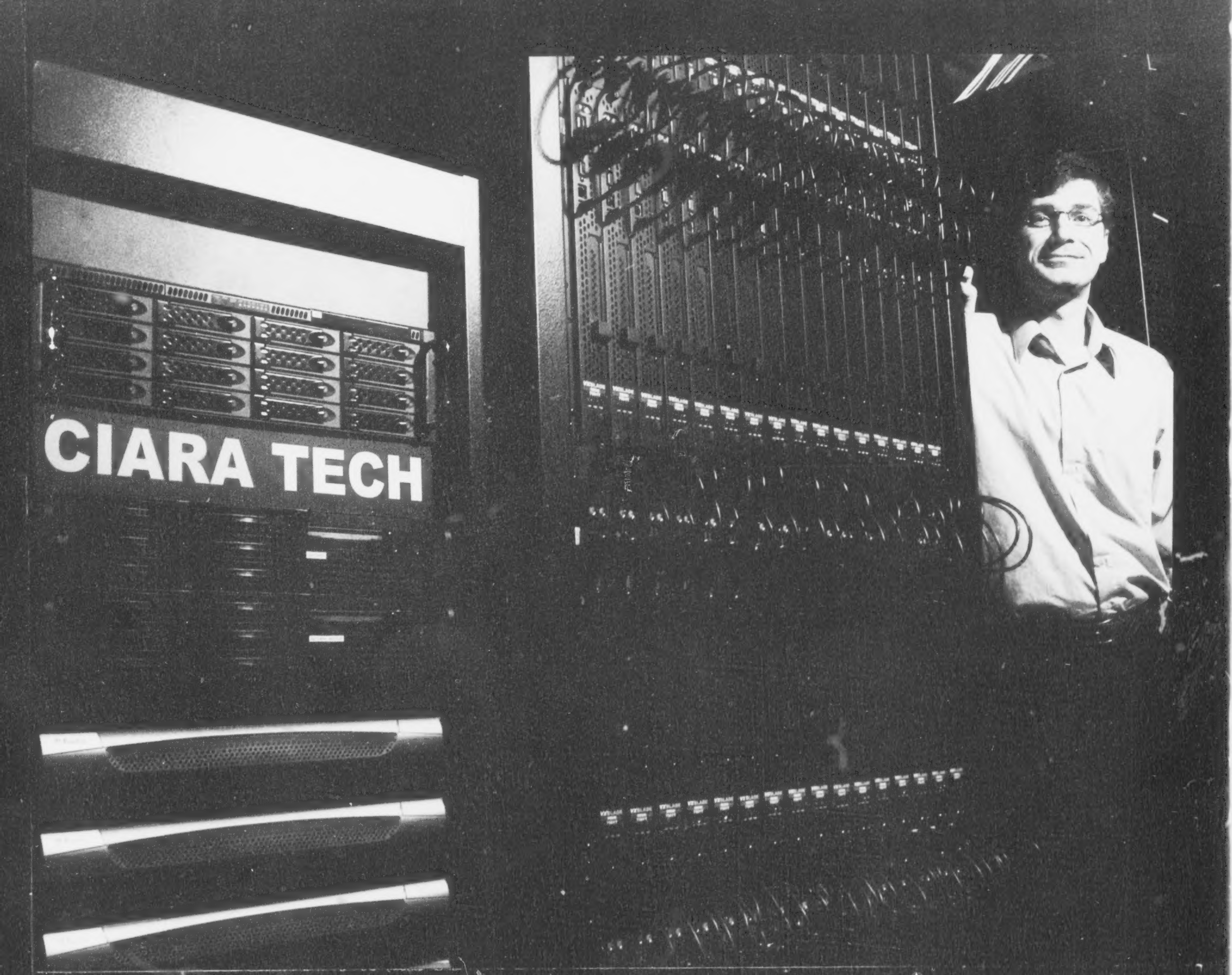
Nearly half of all purchases in Canada are now made with a debit card. In 2003, there were 19 million Canadians – or 86 per cent of the population – who had a debit card. Gebert said Canada has the highest per capita use of debit cards in the world.

DID YOU KNOW?

Nearly half of all purchases made in Canada today are with a debit card.

There are 19 million Canadians, or about 86 per cent of the population, who have a debit card.

Canada has the highest per capita use of debit cards in the world.


CIARA TECH

Super Computer Studies Smallness

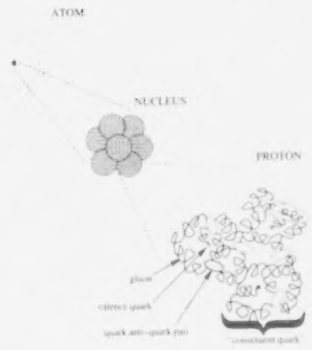
A powerful computer only the size of a five-drawer filing cabinet was installed at the University of Regina in 2004 to help scientists explore the frontiers of smallness. The university's Lattice Quantum ChromoDynamics (LQCD) computer is the most powerful one of its kind in Canada. It is being used to research subatomic matter.

"Every atom in nature is composed of a quantum cloud of electrons surrounding a tiny nucleus," said Dr. Randy Lewis, who joined the university's Physics Department in 1997. "The nucleus of an atom is built from protons and neutrons, which are, in turn, composed of quarks and gluons."

"By hosting Canada's largest LQCD computer, Saskatchewan has defined a leading role for its scientists and its students," Dr. Lewis stated.

Physicists aren't certain if quarks and gluons contain even smaller objects. "No one knows. Quarks and gluons are the frontier of smallness," Dr. Lewis said. "This question is being investigated by physicists all around the world, and the new LQCD computer is the tool with which we are conducting our research here."

Protons and neutrons both have their own distinct and complex arrangements of different quarks, anti-quarks and gluons. These virtual particles in a proton or neutron appear and disappear constantly, as well as strongly interact with each other. This makes them difficult to identify and study.



DID YOU KNOW?

Lattice Quantum ChromoDynamics, or LQCD, are the computer simulations of how subatomic particles interact.

The University of Regina's LQCD computer, installed in 2004, is built from 260 Pentium-4 processors with more than 13,000 Gigabytes of disk space.

The LQCD computer in Regina is only about the size of a five-drawer filing cabinet.

"As a result, theoretical physicists have often resorted to approximate theories to explain how subatomic particles interact, instead of using the more complex and accurate theory called Quantum ChromoDynamics," he added. "And the calculations to apply this theory can only be performed through super-computer simulations called Lattice Quantum ChromoDynamics or LQCD."

Dr. Lewis went on to explain how his team's theoretical research on subatomic matter complements the observational research being done by another team in the University of Regina's Physics Department. "The SPARRO team is taking a "real-life" approach by studying energy traces left by subatomic particles, using specialized detector equipment. The LQCD computer is helping our team find the precise mathematical calculations that explain the behaviour of these subatomic particles. Both approaches are necessary to more fully understand the nature of matter." (The SPARRO project is described in another article in this publication.)

The LQCD computer is built from 260 Pentium-4 processors with more than 13,000 Gigabytes of disk space. Yet, it's only about the size of a filing cabinet. The computer is being used by teams of researchers from institutions across Canada, including York University, Simon Fraser University and the TRIUMF Lab in Vancouver.

Dr. Lewis said there are three basic research goals for the project.

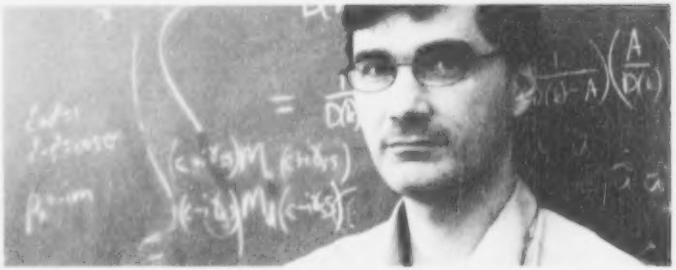
1. "We want to obtain a precise understanding of protons, neutrons and other subatomic particles in terms of the underlying quarks and gluons," he said.

2. Researchers are looking for more exotic forms of matter that can possibly be built from quarks and gluons but have not yet been observed in nature.

3. "We want to look for specific discrepancies between computer simulations and experimental measurements that would provide a clue to new kinds of physics beyond the elementary particles known today," he said.

"By hosting Canada's largest LQCD computer, Saskatchewan has defined a leading role for its scientists and students."

Experts from Canada and around the world come to Regina – some for brief visits, others for longer-term employment – to work on LQCD projects. "This team of talented researchers with this powerful computer equipment will continue to have a significant impact on the world's scientific agenda," Dr. Lewis said.



Dr. Randy Lewis

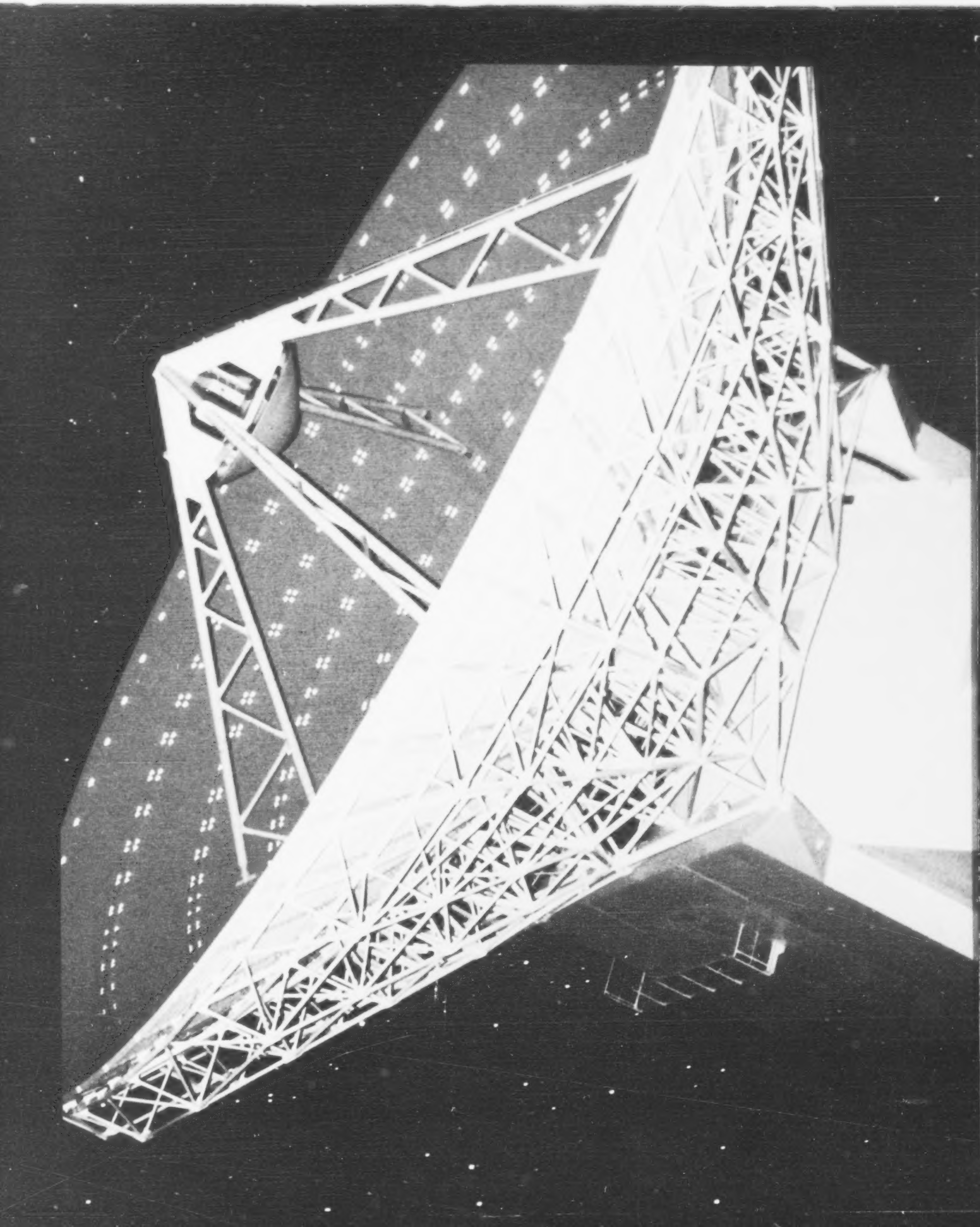
By helping us better understand how atoms work, the LQCD project could contribute to future physics-related breakthroughs in everything from medical equipment to space travel.

DID YOU KNOW?

Protons and neutrons in an atom are composed of quarks and gluons.

Scientists are trying to determine, using the LQCD computer, if quarks and gluons contain even smaller objects.

Regina's LQCD facility is a VXRack™, which is the most compact computer cluster in the world.



SED Systems Antenna Listens to the Galaxy

Night and day, the giant antenna built in Australia is listening. Standing as tall as a 12-storey building, it can swivel 360 degrees, enabling it to "hear" transmissions from a number of satellites deep in space. It's a complicated undertaking where precision is critical to the success of the mission, and central to it all is equipment designed and built by SED Systems of Saskatoon.

SED Systems has been in the business of communications for 40 years – 2005 is the company's official 40th anniversary. Through a partnership of the Canadian Space Agency and the European Space Agency (ESA), Canadian businesses are able to bid on projects that ESA puts forward. SED Systems began the bid to build the giant antenna starting in 1998, and the resulting $23-million contract was the largest ever awarded to a Canadian company under the general budget of ESA.

Don Epp, director of marketing at SED Systems, explained the complexities of building these large antenna systems: "It's pretty detailed and demanding. The antenna tracks deep space probes heading out to the outer reaches of the solar system, and the antenna sends commands to activate and control the probe, as well as receiving information and data."

The giant antenna in Australia "listens" and "talks" to a number of ESA spacecraft, but one of its longest conversations is with the Rosetta spacecraft. The craft is on its way to meet up with a comet called 67P/Churyumov-Gerasimenko, a meeting that won't even take place for nearly another 10 years.

DID YOU KNOW?

Width of the dish of the antenna: 35 metres

Height: 12 storeys

Weight: 600 tonnes

The antenna system is designed for 15 years of operational use.

Even though signals to and from the satellites travel at the speed of light, communications from Earth to a spacecraft can take as long as 100 minutes due to the distance the crafts travel from Earth.

SED Systems marked 40 years in business in 2005.

SED Systems' SMS, a supra-thermal mass spectrometer, was the first foreign instrument to be flown on a Japanese satellite.

Launched in 2004, Rosetta was first sent into orbit around the Earth, then "sling-shot" around Mars in order to gain more speed for its journey. By the end of October 2004, it was already 63 million kilometres away from Earth. Rosetta will sleep for 11 years before being awakened by commands sent from the antenna to allow it to do the job of studying the comet.

The antenna, which was a massive undertaking, is the result of a joint effort of companies from several countries, led by SED Systems as the prime contractor. Due to its sheer size, final assembly of the antenna could only be done on site in Australia.

"It was too big to build in the plant and check out," Epp said. "Large portions of the mechanical structure were built in Europe. We brought the radio frequency components to Saskatoon to integrate and test them here. Finally, all of the subsystems were shipped to the site where they were put together into a working system. From start to finish, the project took about four years."

The surface of the main antenna reflector has to be extremely smooth in order to achieve the performance necessary for deep space communications. The entire surface area of the 35-metre dish must be smooth to within one-half of one millimetre.

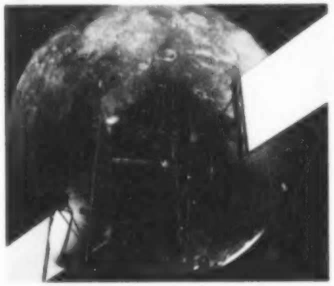
Despite its size, the antenna must also be able to rotate smoothly and accurately point at its targets. "The moving part of the antenna weighs some 600 tonnes," Epp said. "Even though the structure is so large, it can be pointed with a precision of several thousandths of a degree."

The completed antenna in Australia sits at about 120 degrees east longitude. SED Systems is also building a companion antenna for ESA in Spain (at about zero degrees longitude), and there are plans for a third system somewhere in the world at about 120 degrees west longitude. That would give ESA a network of antennas around the globe that can listen or talk to deep space probes at any time of day, regardless of the Earth's position and rotation.

SED Systems technicians were also present when the giant antenna first started up, and the company offers warranty protection and support for its equipment.

"During critical mission phases, like the Rosetta launch, we are asked to go and support the ESA staff and make sure it's going well," Epp said.

The applications for such giant antennas are limited – generally to countries with space programs that need a way to listen in on their equipment far out in space. Epp said that India and China have expressed some interest in SED Systems' products, but nothing is concrete with those countries yet.


Rosetta spacecraft flies past planet Mars

ESA's deep-space antennas are going to have a busy schedule. Besides Rosetta, ESA is listening to Mars Express, a spacecraft that arrived at the red planet in December 2003. By February 2005, Mars Express, which landed on the planet, was delivering information and scientific data of unprecedented quality that is changing the way we look at Mars. ESA is also planning missions to explore Venus with a craft just like Mars Express, and a mission to Mercury called Bepi Columbo is due for launch by 2012.

DID YOU KNOW?

A Saskatchewan satellite ground station provided by SED Systems was the first station in the world to receive remote sensing images of the Earth taken by the first Landsat satellite.

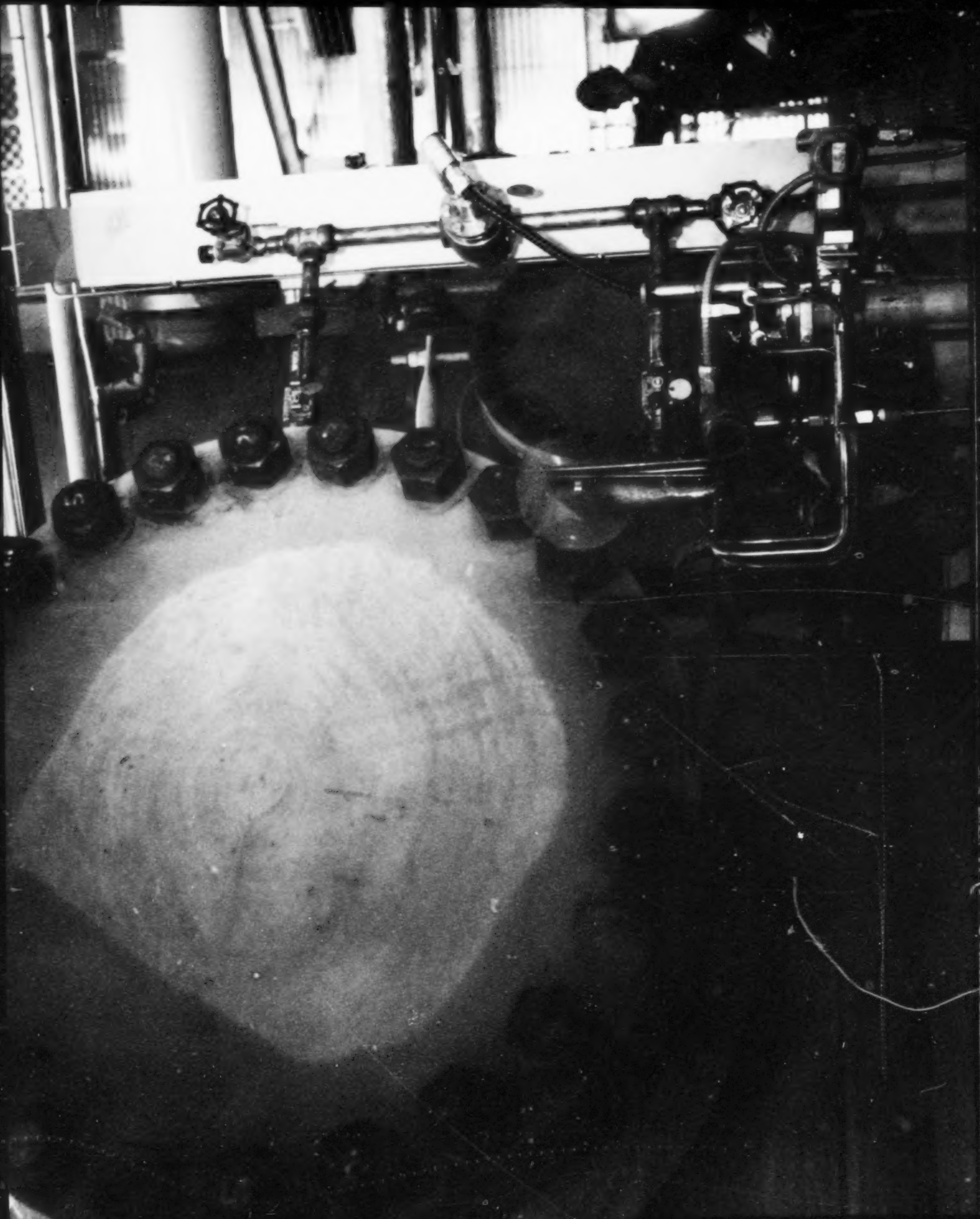
SED Systems provided the ground control stations as well as operations services to support Canada's first remote sensing satellite, RADARSAT-1.

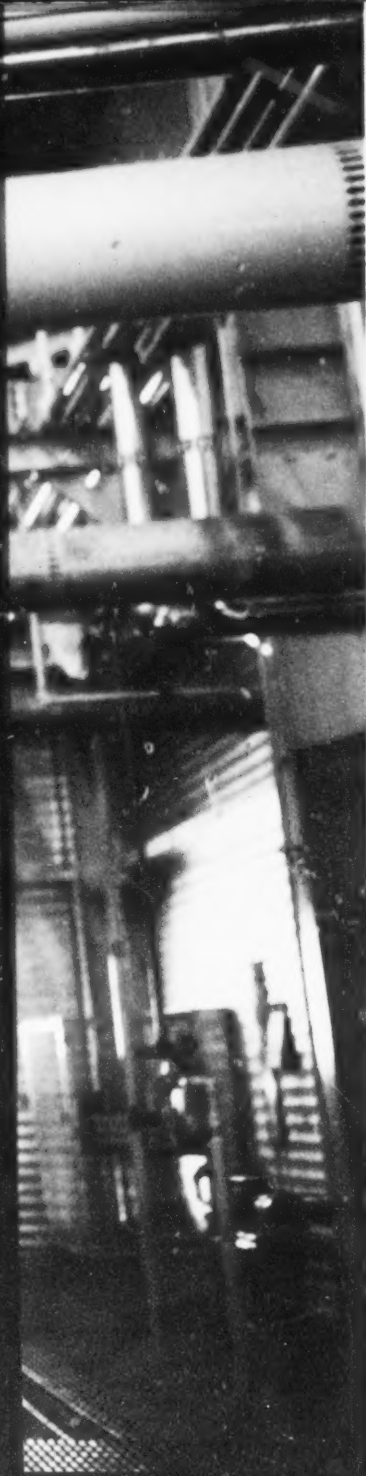
A test system supplied by SED Systems was the first known commercial system for testing communications payloads flying on low-earth orbiting satellites.

SED Systems Access Control and Signalling Equipment was the first in the world to be operating in all four ocean regions.

SED Systems provided the uplink stations for the first-ever digital radio service via satellite operated by WorldSpace.

Source: European Space Agency summary provided by SED Systems





Weyburn CO_2 Storage Project Largest in the World

The Petroleum Technology Research Centre (PTRC) at the University of Regina recently completed a study on the injection of carbon dioxide into a mature oil field that is one of the largest climate-change research projects in the world.

During the four-year study, the PTRC, working with a team of international researchers, successfully monitored the injection of about five million tonnes of carbon dioxide into the Weyburn oil field. Storing this amount of CO_2 is the equivalent of removing 1.3 million cars from the roads for one year. Over the life of the project, it will store a total of 21 million tonnes of CO_2.

The CO_2 injection also helps to extract oil from the field that previously had been unrecoverable, thereby extending the life of oil production for that field by 25 years. That's an important achievement for the economy of the Weyburn area.

The Weyburn project was big news within the global scientific community when the results were released at the seventh International Conference on Greenhouse Gas Control Technologies in Vancouver in fall 2004. This is the world's most important conference on technologies that help reduce the impact of greenhouse gases on climate.

"There was keen worldwide interest in the results," said Dr. Malcolm Wilson, a co-founder of the study and director of energy and environment at the University of Regina. "This wasn't a small pilot test or simulated results. We were able to monitor large volumes of injected CO_2 in a real-world environment."

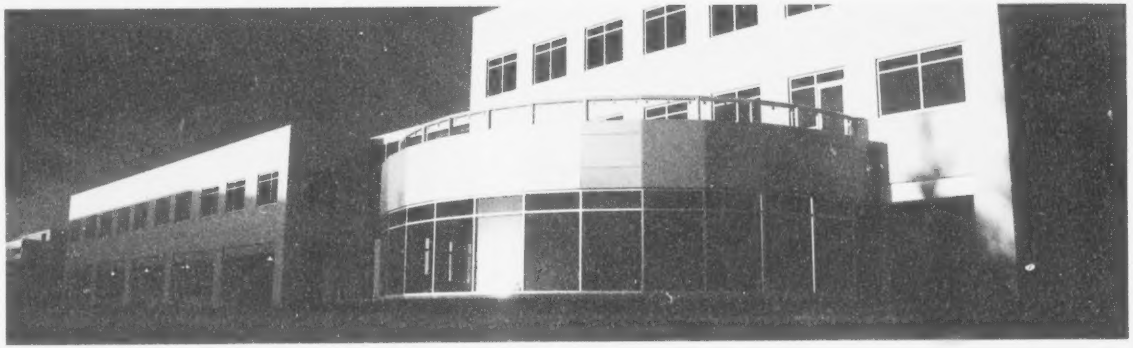
The $40-million project was conducted by the PTRC and endorsed by the International Energy Agency Greenhouse Gas R&D Program. The Weyburn project has become a model of international co-operation between the public and private sectors, as well as research organizations from Canada, Europe, Japan and the United States.

DID YOU KNOW?

The four-year Weyburn study, conducted by the Petroleum Technology Research Centre (PTRC) at the University of Regina, cost $40 million.

The Weyburn project is considered a model of international co-operation, involving the public and private sectors as well as research institutes from Canada, Europe, Japan and the United States. There were 15 sponsors including EnCana, Natural Resources Canada and the United States Department of Energy.

About 5,000 tonnes of carbon dioxide was pumped each day into the Weyburn oil fields over the four-year life of the project.



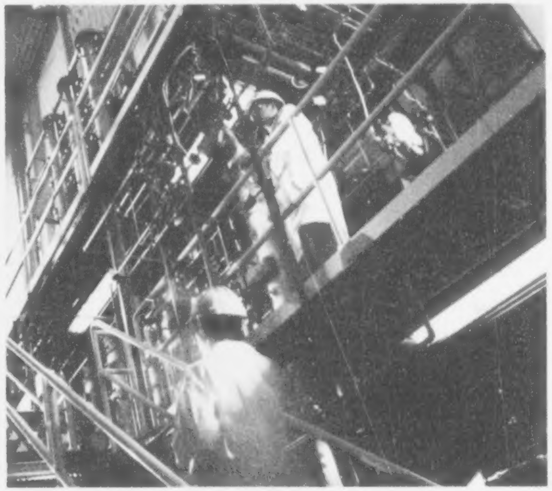
PTRC building in Regina

Research was done in close collaboration with EnCana Corporation, the oil company that operates the Weyburn oil field. EnCana had plans to use carbon dioxide to increase oil recovery in the field that had already produced about 380 million barrels since being discovered in 1954.

Using CO_2 injections to push more oil out of the ground in a field that has produced oil for many years is called enhanced oil recovery (EOR). The Weyburn field was an ideal site for the project because of the amount of oil still to be recovered and the nature of the field itself. Scientists in the research project had access to 50 years of data to help them conduct "before" and "after" analyses of the oil fields to ensure that the CO_2 injection process was effective and safe.

Storing this amount of CO_2 is the equivalent of removing 1.3 million cars from the roads for one year.

"The Weyburn project was the world's first large-scale study on the geological storage of CO_2 in a partially depleted oil field," explained Mike Monea, executive director of the PTRC. "While there are numerous large commercial CO_2-enhanced



Research facilities at PTRC

oil-recovery operations around the world, none of these has undertaken the depth and extent of research that we have."

The concept used in Weyburn is simple. First, compressed CO_2, a known greenhouse gas, is injected into the oil field. The gas mixes with the oil in the little nooks and crannies (pores) in the reservoir rock underground, and helps the oil flow more easily to the nearest pumpjack. Any CO_2 extracted with the oil is separated at the surface and recycled for use in the EOR process. The produced oil then begins its journey through the petroleum refining system and on to the consumer.

By using repeat seismic surveys, scientists are able to "see" the CO_2 in the ground and determine its path through the reservoir as it mixes with the oil and moves towards pumpjacks. The CO_2 is supplied via a 325-kilometre pipeline from the Dakota Gasification Company's plant at Beulah, North Dakota.

"The Weyburn project is good news for addressing climate change because it proves that you can safely store 5,000 tonnes of CO_2 per day in the ground rather than venting this greenhouse gas into the atmosphere," said Dr. Wilson.

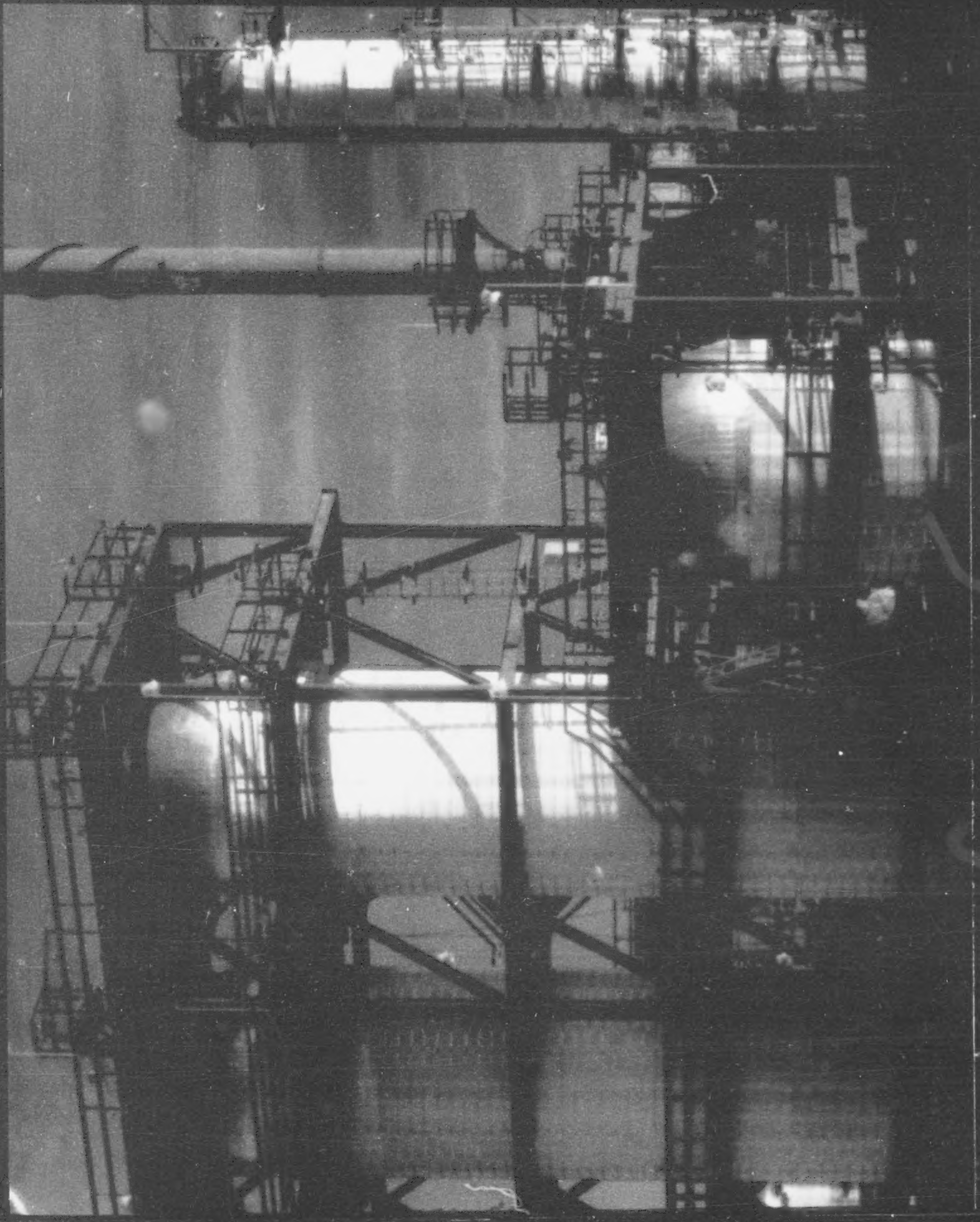
Pumpjack in the Weyburn CO_2 flood area.

The orange is the CO_2, the blue is injected water. The water keeps the CO_2 (since the CO_2 is lighter) in the upper production zone where the target oil is.

DID YOU KNOW?

The Weyburn oil field has successfully stored an estimated five million tonnes of carbon dioxide – the equivalent to taking about one million cars off the road for one year.

The Weyburn oil field was selected for the international study because detailed geological records, as well as almost 50 years of production history, were readily available for scientists.



Heavy Oil Upgrader the First in Canada

Many people are surprised to learn that Saskatchewan is the second largest oil-producing province in Canada, contributing 21 per cent of the country's annual production. However, what we currently pump from the ground is only a fraction of what we are capable of producing. We have 35 billion barrels of known oil reserves in the province, but about half of this amount is heavy oil that is hard to recover and refine.

That's why Saskatchewan became home to Canada's first commercial heavy oil upgrader in 1988. The NewGrade Energy Inc. upgrader was one of the first to upgrade heavy crude oil so that it can be refined into such petroleum products as gasoline and diesel fuel. A much simpler upgrading process has been used since the 1960s in Alberta for upgrading oil-sands oil into usable petroleum, although the process is considerably different.

The NewGrade upgrader is located next to the Consumers' Co-operative Refineries Ltd.'s light-crude oil refinery at the north end of Regina. The upgrader is fully integrated with the refinery, making it easy to transfer the upgraded crude oil to the refinery for final processing into petroleum products.

"Although upgrading had also been going on in the Alberta oil sands and in a number of other countries around the world before 1988, this was an important scientific achievement for Canada and Saskatchewan," explained Peter Wyant, a member of the NewGrade board of directors. Wyant is also an investment director at Crown Investments Corporation, a provincial Crown corporation that owns half of the upgrader. "NewGrade was plowing completely new ground because of the extent of the upgrading that had to be done," Wyant added.

DID YOU KNOW?

The NewGrade upgrader, Canada's first commercial heavy oil upgrader, opened in 1988 next to the Consumers' Co-operative Refineries Ltd.'s oil refinery in Regina.

Heavier, or more viscous, crude oil is refined into synthetic crude oil at the NewGrade facility to be used as the feedstock for the Co-op and other refineries.

The refinery makes gasoline and diesel fuels from the synthetic crude oil.

Saskatchewan is Canada's second largest oil-producing province after Alberta, with about 35 billion barrels of known oil reserves in place. Half of that is heavy oil.

Before the NewGrade upgrader was built, Saskatchewan shipped most of the heavy oil it extracted to the U.S., where it was used primarily to make asphalt for roads. U.S. demand for our heavy oil exports fluctuated according to the time of year, and so did the price we received. There was no refinery in Canada that could upgrade substantial volumes of our heavy oil.

By having an upgrader in Saskatchewan, the Co-op refinery could process heavy crude into much more valuable lighter crude, right here in the province. This provided Saskatchewan oil producers with an expanded, more stable market and encouraged increased production of heavy oil. It was an important step in the growth of Saskatchewan's oil industry.

The NewGrade upgrader uses a chemical reaction process to change the molecular structure of the heavy oil into something more usable. Here's a brief explanation of the process:

- There are two main challenges to turning heavy oil into a lighter, more usable product. First, heavy oil contains a high level of sulphur and other undesirable components that have to be reduced, or removed completely, before the oil can be processed into the gasoline you put in your car. Second, oil is made up of hydrogen and carbon molecules. In heavy oil, there is too much carbon compared to hydrogen, so this ratio has to be changed.
- The first step in the upgrading process is to add hydrogen gas to the crude, which triggers a chemical reaction during which the crude is boiled under pressure. This reaction removes most of the sulphur and increases the level of hydrogen to the desired level. At this point, most of the heavy crude can be sent to the Co-op refinery for final processing.

Consumers' Co-operative Refineries Ltd.'s oil refinery in Regina

- However some of the crude still contains undesirable substances, such as heavy metals and salt. This crude is taken through an additional distillation process to remove the heavier components before being sent to the refinery.
- These heavier components are then put through a heat process where the remaining carbon is converted into a solid. This solid carbon product, called "petroleum coke," is sold to the aluminum industry to be used in making aluminum. The remaining liquids are light enough to be processed into gasoline and diesel fuels in the refinery.

The NewGrade facility, which cost $800 million to build, now processes about 60,000 barrels of heavy oil a day. Four years after NewGrade began operations, Saskatchewan's second heavy oil upgrader opened near Lloydminster in Saskatchewan. The $1.67-billion Bi-Provincial Upgrader, now owned by Husky Energy, processes about 70,000 barrels of heavy oil a day.

Saskatchewan's two heavy oil upgraders have helped expand markets for the province's plentiful heavy oil reserves and are major contributors to the provincial economy.

DID YOU KNOW?

In 2003 oil and gas contributed eight per cent of Saskatchewan's total economy (Gross Domestic Product) and created about 24,000 direct and indirect jobs.

Saskatchewan's first commercial crude oil discovery was made in 1944.

POWER
energy

Hydrogen-Fuelled Trucks Hit the Road in Saskatchewan

Saskatchewan is a world leader in the development of dual-fuel hydrogen and petroleum-fuelled vehicles that could help reduce the use of fossil fuels and the release of greenhouse gases into the atmosphere.

Saskatchewan Research Council (SRC) in Saskatoon unveiled the world's first modified pickup truck fuelled by a combination of hydrogen and diesel in 2004 and in January 2005 introduced a hydrogen-gasoline model.

SRC developed the technology and applied it to a 2004 General Motors pickup truck with a six-litre gasoline engine. The vehicle runs on a combination of hydrogen and gasoline with the substitution rates of hydrogen up to 100 per cent. The truck also can run on gasoline alone when required.

The hydrogen-gasoline truck can operate on 100 per cent hydrogen in most urban driving conditions.

"There is a lot of research taking place around the world to develop technology to allow hydrogen to be used as an energy source," explained Sheldon Hill, principal research engineer in Alternative Energy Products at SRC.

"Unlike most of our fossil fuels used to fuel vehicles today, hydrogen can be perpetually produced to make a synthetic or man-made fuel."

Hydrogen can be released from water through a process called electrolysis.

"This process uses electricity that can be produced from renewable sources such as wind and solar energy," he said. "As a result, hydrogen is considered to be a sustainable fuel that can take us beyond the finite limits of fossil fuels."

DID YOU KNOW?

Saskatchewan Research Council (SRC) unveiled the world's first pickup truck fuelled by hydrogen and diesel in 2004 and then unveiled a second truck nine months later fuelled by hydrogen and gasoline.

The proprietary system developed in Saskatchewan is considered a critical technology to bridge from fossil-fuelled internal combustion engines of today to the fuel cell vehicles of the future.

Hydrogen is normally a gas and is the lightest of all elements, which makes it more difficult to store than conventional fuels.

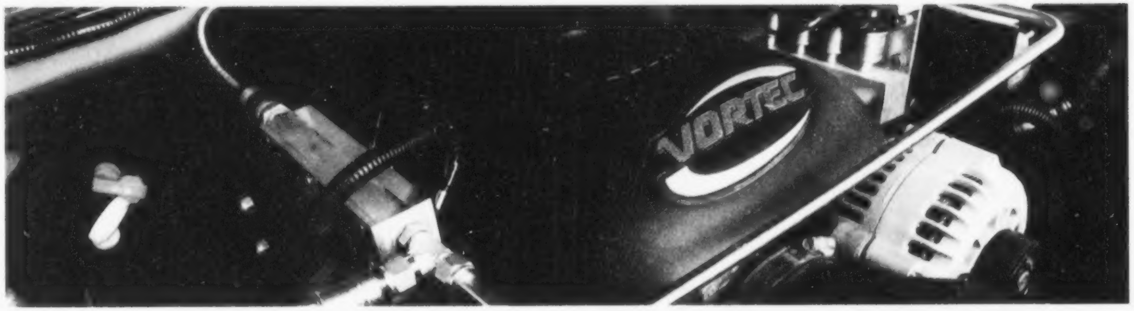
Another advantage is that hydrogen is one of the cleanest possible fuel sources. The hydrogen-gasoline truck can operate on 100 per cent hydrogen in most urban driving conditions, releasing primarily water vapour into the air in the combustion process. This substantially reduces air pollution and greenhouse gas emissions. When using fossil fuels, vehicles emit exhaust fumes that includes carbon-based substances such as carbon dioxide, carbon monoxide and hydrocarbons – all major pollutants of the Earth's atmosphere.

Hydrogen clearly has potential, but with so many millions of vehicles powered by gasoline and diesel today, it's almost impossible for new or alternative energy-fuelled engines to compete.

"SRC's hydrogen project involves the development of a transitional or bridging technology that will promote the adoption of hydrogen use and decrease our dependency on fossil fuels," Hill said.

"The development of the dual-fuel hydrogen vehicle technology is a significant achievement since these vehicles represent perhaps the lowest-cost means of moving away from fossil fuels into hydrogen."

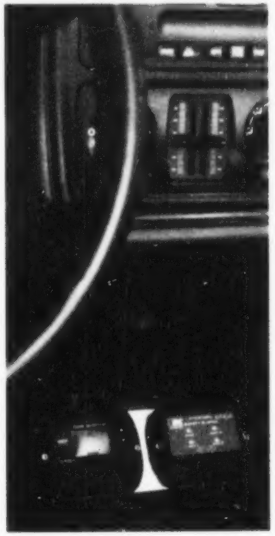
The dual-fuel vehicles are more practical for today's drivers who would find it extremely difficult accessing hydrogen-fuelling stations on a regular basis. It is too early in the development of hydrogen fuel to have a network of fuelling stations across the country.



"In addition to providing environmental benefits, these vehicles provide the reliability and performance expected by the public," he said. There has been no loss of power in either pickup truck when using the blend of hydrogen and diesel or hydrogen and gasoline.

"These advantages should allow dual-fuel hydrogen vehicles to penetrate the transportation market first, which will help promote the development of hydrogen-fuelling stations that will be necessary to support the hydrogen fuel cell vehicles of the future."

The proprietary, first-generation hydrogen systems developed in Saskatchewan are a critical bridging technology as the transportation industry moves towards the fuel cell vehicles of the future.



1 H hydrogen 1.00794

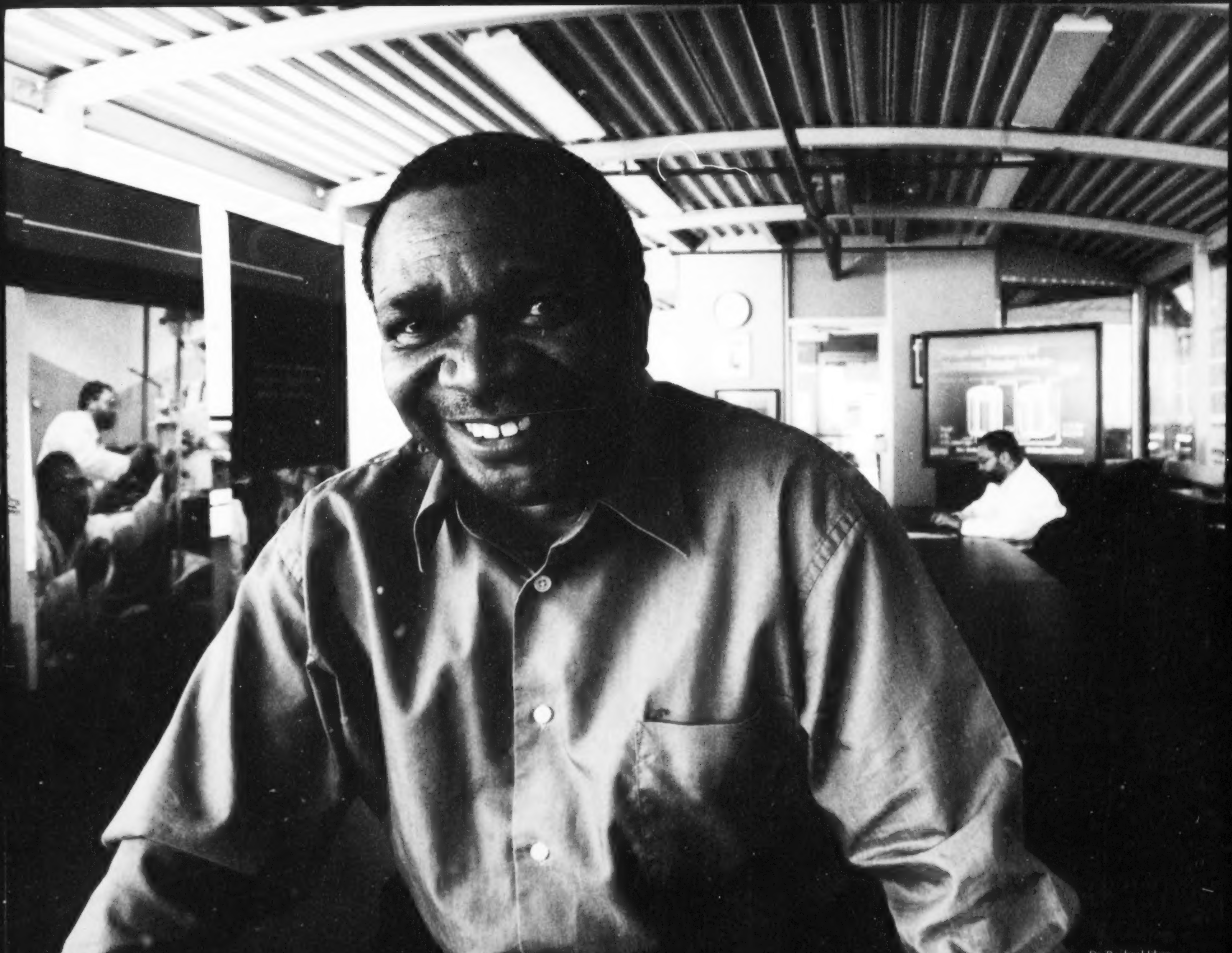
DID YOU KNOW?

Hydrogen is commonly stored as a compressed gas onboard hydrogen-fuelled vehicles.

Almost every major vehicle manufacturer is developing hydrogen-powered fuel cell vehicles.

Hydrogen can be produced from water, fossil fuels or biomass.

Canada is a world leader in the research and development of hydrogen fuel cells and hydrogen-related technologies.



Dr. Raphael Idem

First to Convert Natural Gas into Hydrogen

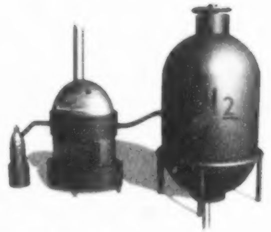
Imagine the car of the future: its hydrogen fuel cell supplying the power, and a fine mist of water spraying out behind as the only exhaust. Transportation is currently the biggest contributor to greenhouse gas emissions in Canada. That's why there is so much research underway to find alternative energy sources to fossil fuels, which when burned emit the greenhouse gas carbon dioxide into the air. Hydrogen is proving to be one of the most promising energy alternatives with no harmful emissions.

Although it's a big leap from cars powered by gas to those powered by hydrogen, a University of Regina engineering professor has developed a new hydrogen fuel process that will help the automobile industry make the transition. Dr. Raphael Idem worked on a system for converting an existing fossil fuel – natural gas – into harmless hydrogen using a process called catalytic conversion. He and his research team are the first in the world to develop a conversion method that results in a stable source of hydrogen.

"The biggest benefit is to the environment," Dr. Idem says. "We can continue to use fossil fuel resources, but in a more responsible way."

He explained the basics of his conversion method: "The process of splitting fossil fuel into carbon dioxide and hydrogen is a catalytic process . . . a catalyst must be used in order to make it happen in real life. Otherwise, it is an impossible process."

The process nearly proved impossible for Dr. Idem and his team. Previous catalysts created by other researchers only worked for a short amount of time, then broke down and caused the whole process to stop.



HTC Natural Gas / Hydrogen Reformer

DID YOU KNOW?

The process of splitting fossil fuel into carbon dioxide and hydrogen is a catalytic process. A catalyst must be used in order to cause the chemical reaction that will produce a stable form of hydrogen.

This particular process for turning natural gas into hydrogen gets more usable energy from natural gas (at least 1.4 times more) than just burning the gas in the most efficient turbine or engine.

"The basic challenge we had to overcome was finding the right catalyst," Dr. Idem said. "We tried several formulations – obviously it won't just work the first time! We had background on ones that hadn't worked before, so we were able to use that information to find something that would work. The catalyst formulation we finally developed enables the process to go as long as we wish."

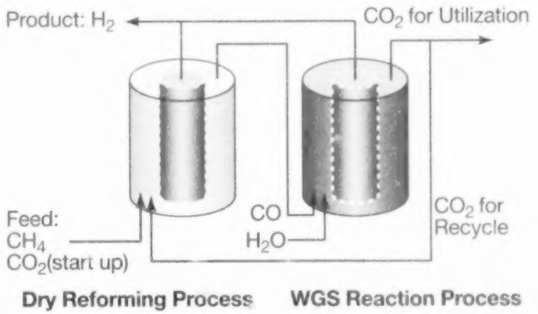
Over the course of a few months, Dr. Idem and his team worked to perfect the formulation they had developed to ensure the best performance from the process. Testing a new technology and new formulation meant starting everything from scratch. "The equipment to do it didn't exist, so we had to design the equipment and get someone to fabricate the parts," he explained.

Dr. Idem and his research team are the first researchers in the world to develop a dry conversion method that results in a stable source of hydrogen.

The formulation of the catalyst is a closely guarded secret until the research is finished and ready to be tested for different uses and projects. But Dr. Idem can say that his catalytic conversion process could eventually be used to generate power for all kinds of uses.

One possible application could be right in your own home. A catalytic converter unit could be attached to a regular natural gas-burning furnace. The unit would use Dr. Idem's process to convert the natural gas emissions from the furnace into hydrogen instead of allowing the emissions to go out the chimney, which is the current practice for gas furnaces.

"We are able to use this process to make a compact design in such a way that, if you put it in your house, it's no bigger than a filing cabinet,"

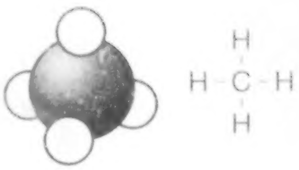


Dr. Idem said. "Hydrogen that is produced goes into a fuel cell where it can then convert into energy or heat, with the byproduct being water."

Having power units like this could mean spending less time in the dark when there's a power outage. "If something happens right now, entire sections of an area's power grid go down, and you can't always find where the problem is right away," said Dr. Idem. "Through distributed energy production (such as having a fuel cell in the house), if you happen to be unlucky enough to have a failure, it affects only you – and you can easily isolate where it happened."

Dr. Idem believes the catalytic conversion process is a realistic middle ground in the struggle to be more responsible with our environment. Alternative fuels such as biomass and agricultural byproducts will be important energy sources in the long-term future, but he said his process helps deal with the reality that we are still very dependent on using fossil fuels for the foreseeable future.

"Presently, it's difficult to say, 'I want to remove greenhouse gas from cars on the streets,' but we envisage using our process to deliver hydrogen similar to the way today's gas station operates. You would drive up and hook up your car to the pump, except what is pumped into the tank is hydrogen rather than gasoline. When you use hydrogen to drive the car, what comes out as a byproduct is water."



Methane molecule

DID YOU KNOW?

This process produces much more energy in the form of hydrogen than what the natural gas actually contains: a molecule of natural gas delivers energy from four hydrogen atoms (CH_4), while the conversion process results in eight hydrogen atoms, with the extra four hydrogen atoms coming from water.

Each Canadian is responsible, on average, for five tonnes of greenhouse gas emissions every year.

Gardiner Dam
Largest Earth-Filled Dam of its Day

A dream that began in the dust bowl era of the 1930s to create a clean, safe and reliable supply of water for most of southern Saskatchewan became a reality in 1967 and continues to be a major factor in the lives of thousands of people each day.

Turn on a tap at home or school in Saskatchewan and you may just be enjoying the benefits from the South Saskatchewan River Project. The Gardiner Dam is located 25 kilometres downstream from the town of Elbow on the South Saskatchewan River. It was the world's largest earth-filled dam when it was officially opened in 1967.

The project took eight years to complete and required 65 million cubic metres of earth-fill to create a dam that is 64-metres high and five kilometres long.

The Gardiner Dam opened in conjunction with the Qu'Appelle River Dam and helped to create Lake Diefenbaker. The 225-kilometre long reservoir was designed as a multi-purpose source of water for irrigation, industry, human consumption and recreation. Today, the water from Lake Diefenbaker is widely used.

"It's the water supply for virtually half of Saskatchewan today, including the cities of Regina, Saskatoon and Moose Jaw, as well as being the source of the pipeline system that supplies the communities of Humboldt, Melfort and Wakaw," explained Doug Johnson, director of basin operations for the Saskatchewan Watershed Authority.

DID YOU KNOW?

Gardiner Dam, located 25 kilometres downstream from Elbow on the South Saskatchewan River, was the world's largest earth-filled dam when it was officially opened in 1967. It is still Canada's largest earth-filled dam.

It took eight years to complete construction of the Gardiner Dam. The dam used 65 million cubic metres of earth-fill and was a remarkable five kilometres long.

The Gardiner Dam opened in conjunction with the Qu'Appelle River Dam and helped to create Lake Diefenbaker, a 225-kilometre long reservoir.

There are about 800 kilometres of shoreline along Lake Diefenbaker, named to honour John G. Diefenbaker, who was Prime Minister of Canada from 1957 to 1963 and a Member of Parliament from Saskatchewan for 39 years.

The dam is named in honour of James Gardiner, who was the Premier of Saskatchewan from 1926 to 1929 and again in 1934 to 1935 before he resigned to run for federal office. Gardiner continued to advocate for the need of a reliable water supply when he was elected to the House of Commons and then became Canada's Minister of Agriculture in 1944.

A federal-provincial agreement to develop the South Saskatchewan River Project received unanimous approval by Parliament in 1958. The Prairie Farm Rehabilitation Administration (PFRA), a federal government agency, accepted the engineering and construction challenge. Although it took eight years to complete, the workmanship still stands as a scientific achievement decades later. Cost of constructing the Gardiner Dam and Qu'Appelle River Dam was about $120 million, but the price tag to replace the structures would be about $1 billion today.

"It's the water supply for virtually half of Saskatchewan today."

"What many people don't recognize is that the Gardiner Dam was redesigned a couple of times during its construction, owing to the difficulty in determining the strength of its clay shale foundation," explained Johnson, a water resource engineer. The final constructed cross-section of the dam had a significantly wider base and much more fill material than the pre-1959 design.

The Gardiner Dam is used to moderate the flow of water on the South Saskatchewan River with its spillway that is more than one kilometre in length. The spillway itself is made from 260,000 cubic metres of concrete and is able to discharge a remarkable 7,500 cubic metres of water per second.

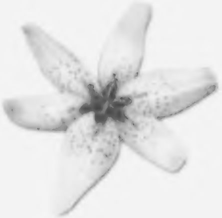
Output from dam

Controlling the flow from the South Saskatchewan River into Lake Diefenbaker, the Gardiner Dam stores and releases water to serve a variety of needs, including irrigating 37,000 hectares of agricultural land, providing drinking water to cities and towns, and power generation at three hydroelectric plants.

Lake Diefenbaker boasts a shoreline of almost 800 kilometres, virtually the distance from Regina to Calgary, providing an abundance of wildlife habitat and recreational opportunities.

The Province of Saskatchewan took ownership of the project in 1969, but the PFRA continued to operate the project until 1994. At that point, the province took over responsibilities for the operations of the Gardiner and Qu'Appelle River Dams. Those duties now are the responsibility of the Saskatchewan Watershed Authority, established in 2002 to manage and protect water quantity and quality in the province.

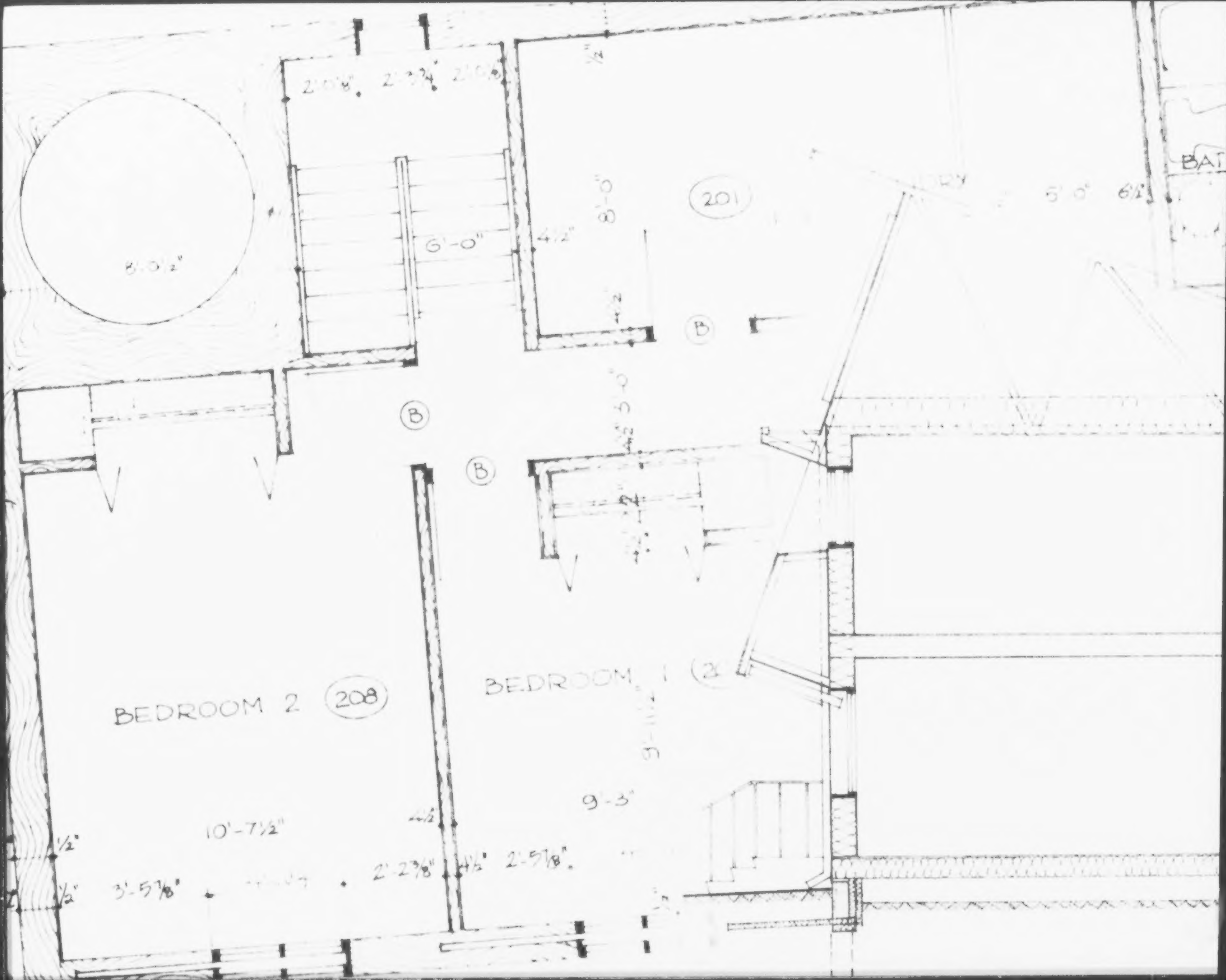
Aerial photo of dam



DID YOU KNOW?

The Gardiner Dam is named to honour James Gardiner, a Saskatchewan Premier who served for five years in the 1920s and 1930s, and who later was elected to the House of Commons and served as Minister of Agriculture.

Water for the cities for almost half of the people in the province, including those living in Moose Jaw, Regina and Saskatoon, is provided by the South Saskatchewan River system.


BEDROOM 2
208
BEDROOM 1
201
B
B
B
6'-0"
8'-0"
4½"
9'-3"
10'-7½"
3'-5⅝"
2'-2⅜"
4½"
2'-5⅛"
8'-0½"
5'-0"
6½"

One of North America's First Energy-Efficient Houses

An energy-efficient home built in Regina almost 30 years ago was one of the first conservation demonstration houses constructed in North America.

Over the years, more than 30,000 people toured the no-nonsense, two-storey structure that is roughly in the shape of a cube. After a five-year scientific monitoring period, the house was eventually sold by the provincial government to a family.

Built in 1977, the house helped establish some energy-conserving standards for the Canadian housing industry that remain in place to this day. The Regina house was super-insulated for the era, airtight and equipped with a pioneering, air-to-air heat exchanger for ventilation. It had no furnace. Instead, the home was heated with a solar heating system designed specifically for Saskatchewan's extreme climate.

The energy conservation features were so effective that the builders estimated, on the coldest day of the year with a house party for 40 people, the windows would have had to have been opened because the heat would have been so intense!

Energy consumption for the home was only about 15 per cent of the levels used by a traditional house.

Saskatchewan Research Council (SRC) was the research and project manager for the conservation house. Other partners included the Saskatchewan Housing Corporation, Saskatchewan Power, the National Research Council's Division of Building Research, and the engineering faculties at both the University of Saskatchewan and the University of Regina. Land was provided by the City of Regina.

DID YOU KNOW?

The energy-efficient home built in 1977 in northwest Regina was among the first conservation demonstration houses in North America.

Energy consumption levels were 85 per cent less th... ...ith a traditional house

Systems and te hniques used in the Regina project, such as air tightness, have become standards used by the Canadian Home Building Association to this day.

The house had no furnace.

Using air-to-air heat exchangers for ventilation was a pioneering technique.

Rob Dumont worked on the project for SRC. "The house had a large impact on the house-building community nationally and internationally. Several of the innovations are now widely used," said Dumont, who now is the section leader of SRC's building performance unit.

"The conservation house demonstrated that houses could be built significantly tighter and more energy efficient. The Canadian R-2000 program (federal government energy-efficient housing standards) now has a requirement for air tightness that recognizes this important fact."

"The air-to-air heating unit in the house was the first of its kind in North America, and these heat exchangers are now produced in the tens of thousands each year in Canada and the U.S.," he said.

The house's use of passive solar heating, which was very uncommon at the time, has since become mainstream among advanced home designers today.

Another landmark innovation was to increase the amount of insulation. "Since the house was built, wall insulation levels on average have roughly doubled from 62 mm of insulation to 140 mm of insulation," Dumont said. "However, that's still not near the super-insulation levels used on the conservation house that were around 300 mm thick."

Energy consumption for the home was only about 15 per cent of the levels used by a traditional house. The house was designed to expose a minimum amount of exterior surface area per square foot of floor space. There was no basement. The exterior finish was dark brown

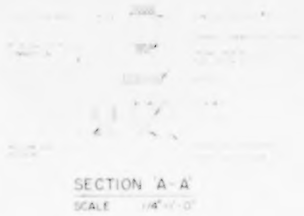
cedar siding. Since dark colours absorb heat from the sun, this enabled the house to act as a giant solar energy collector.

Even the landscaping was designed to increase thermal efficiency. Deciduous trees on the south side of the house provided shade in summer and allowed solar heat to enter the windows in the winter.

The house had energy-efficient kitchen appliances. The energy from the waste water was even recycled using an experimental heat-recovery system. Almost all of the heat required was supplied by a solar heating system that used radiant energy from the sun for fuel.

Dumont is concerned that not enough people are embracing energy conservation tools and techniques. "Kids today need to be very aware of energy consumption because the peak in world oil consumption is expected in 10 or 15 years," he said.

"Buildings use one-third of all energy in society. If we don't use energy conservation techniques, what will happen to our environment in the future?"



DID YOU KNOW?

The energy conservation features were so effective that the builders estimated, on the coldest day of the year with a house party for 40 people, the windows would have had to have been opened because the heat would have been so intense!

Photography Reference

6 Bovine x-ray courtesy Canadian Light Source Inc., University of Saskatchewan

13 Canadian Light Source Inc. building, courtesy Canadian Light Source Inc., University of Saskatchewan

14 Synchrotron courtesy Canadian Light Source Inc., University of Saskatchewan

16 PCK protein (diabetes) courtesy Dr. Louis Delbaere, Department of Biochemistry, University of Saskatchewan

16 Synchrotron diagram courtesy Canadian Light Source Inc., University of Saskatchewan

17 ATP image courtesy Dr. Louis Delbaere, Department of Biochemistry, University of Saskatchewan

18 Dr. Herzberg speaking courtesy University of Saskatchewan Archives

20 Telegram courtesy University of Saskatchewan Archives

21 Postage stamp courtesy Canada Post

24 Dr. Lemieux courtesy National Research Council

25 Sucrose molecule courtesy National Research Council

26 Construction of calorimeter module courtesy SPARRO

28 GlueX detector rendering courtesy Dr. Zisis Papandreou, University of Regina

29 GlueX detector's innards rendering courtesy Dr. Zisis Papandreou, University of Regina

32 PUF sampler courtesy Dr. Bailey, Department of Chemistry & Biochemistry, University of Saskatchewan

34 Propeller image courtesy Antonello Paone, Rome, Italy, Britannic 2003

36 Rusticles image courtesy Droycon Bioconcepts Inc

36 Weights image courtesy Droycon Bioconcepts Inc

37 Close-up rusticles image courtesy Droycon Bioconcepts Inc

37 Bacterial etching image courtesy Droycon Bioconcepts Inc

42 Dr. Lorne Babiuk courtesy VIDO, University of Saskatchewan

44 Laboratory image courtesy VIDO, University of Saskatchewan

45 *E. coli* bacteria image courtesy Dr. Ilan Rosenshine and Dr. Brett Finlay

45 International Vaccine Centre rendering courtesy VIDO, University of Saskatchewan

49 Dr. Keith Downey image courtesy Western Producer

50 Barley germination image courtesy Prairie Malt Ltd.

52 Flexibox image courtesy Prairie Malt Ltd.

62 Cobalt-60 unit image courtesy University of Saskatchewan Archives

64 Decommissioning of cobalt-60 unit image courtesy Dr. Sylvia Fedoruk

65 Demonstration of cobalt-60 unit courtesy University of Saskatchewan Archives

65 Dr. Harold Johns with cobalt unit courtesy University of Saskatchewan Archives

66 Freeze-fracture image courtesy Dr. Marianna Foldvari, University of Saskatchewan

69 Biphasic vesicle diagram courtesy Dr. Marianna Foldvari, University of Saskatchewan

73 Ultrasound images courtesy Dr. Roger Pierson, University of Saskatchewan

77 M-DNA helix courtesy Dr. Jeremy Lee, University of Saskatchewan

86 Fibre optics image courtesy SaskTel

96 Avian diagram courtesy Dr. Randy Lewis, University of Saskatchewan

98 SED Systems antenna image courtesy SED Systems and European Space Agency

100 Antenna images courtesy SED Systems and European Space Agency

101 Rosetta spacecraft image courtesy European Space Agency

108 PTRC building courtesy Petroleum Technology Research Centre

109 Pumpjack image courtesy Petroleum Technology Research Centre

109 Oil and water diagram courtesy Petroleum Technology Research Centre

116 Hydrogen Fuelled truck image courtesy Saskatchewan Research Council

120 Hydrogen reformer diagram courtesy Dr. Raphael Idem, University of Regina

121 Dry reforming process/WGS reaction process diagram courtesy Dr. Raphael Idem, University of Regina

122 Dragline image courtesy Saskatchewan Archives Board (R-A16436-3)

125 Output from dam image courtesy Agriculture and Agri-Food Canada (#98-07-013)

125 Aerial image of dam courtesy Agriculture and Agri-Food Canada (#89-07-340)

126 Blueprints of energy-efficient house courtesy Anne and Bob Jackson

126 Blueprints detail of energy-efficient house courtesy Anne and Bob Jackson

129 Energy-efficient house courtesy Saskatchewan Research Council

All other photography courtesy Saskatchewan Industry and Resources